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# GROUND-WATER MONITORING COMPLIANCE PROJECTS FOR HANFORD SITE FACILITIES ANNUAL PROGRESS REPORT FOR 1987

S. H. Hall



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Pacific Northwest Laboratory
Richland, Washington 99352

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SUMMARY

This report describes progress during 1987 of five Hanford Site groundwater monitoring projects. Four of these projects are being conducted according to regulations based on the federal Resource Conservation and Recovery Act of 1976 and the state Hazardous Waste Management Act. The fifth project is being conducted according to regulations based on the state Solid Waste Management Act.

The five projects discussed herein are

- 300 Area Process Trenches
- 183-H Solar Evaporation Basins
- 200 Areas Low-Level Burial Grounds
- Nonradioactive Dangerous Waste Landfill
- Solid Waste Landfill.

For each of the projects, there are included, as applicable, discussions of monitoring well installations, water-table measurements, background and/or downgradient water quality and results of chemical analysis, and extent and rate of movement of contaminant plumes.

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## INTRODUCTION

This report describes calendar year (CY) 1987 progress for five Hanford Site ground-water monitoring projects:

- 300 Area Process Trenches [Resource Conservation and Recovery Act (RCRA) interim-status assessment level]
- 183-H Solar Evaporation Basins (RCRA interim-status assessment level)
- 200 Areas Low-Level Burial Grounds (RCRA interim-status detection level)
- Nonradioactive Dangerous Waste Landfill (RCRA interim-status detection level)
- Solid Waste Landfill (detection level).[a]



The first four ground-water monitoring projects were designed according to the ground-water monitoring requirements given in the federal Resource Conservation and Recovery Act of 1976, as amended and implemented in 40 CFR 265, Subpart F (EPA 1987); and the state Hazardous Waste Management Act, as amended and implemented in the Washington Administrative Code (WAC) 173-303-400. The fifth project was designed to meet ground-water monitoring requirements contained in the state Solid Waste Management Act and implemented in WAC 173-304-490 [Washington State Department of Ecology (hereafter called Ecology) 1986a, 1986b].

The projects for the 300 Area and 183-H basins are being operated as alternate ground-water monitoring systems under 40 CFR 265.90(d). Under 40 CFR 265.93(d)(7), the owner/operator must continue to report the rate, concentrations, and extent of migration of the hazardous waste in the ground water on a quarterly basis. The quarterly reports for 1987 (PNL 1987a,b,c,d) provided detailed information on monitoring activities and results. Under

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40 CFR 265.94(b)(2), an annual report containing the results of the assessment monitoring project is required, and this report summarizes the 1987 results.

The results of chemical analyses and statistical evaluations are included herein for three detection-level projects. Work at three other projects, the 1324-N/NA ponds, and the 1301-N and 1325-N cribs in the 100-N Area, was initiated in the last quarter of 1987 with the drilling of four ground-water monitoring wells and initial ground-water sampling. Discussion of the monitoring results will be included in the annual progress report for 1988.

Some details, with illustrative figures such as water-table maps and plume configuration maps, are included, but interpretation of these results is reserved for the characterization reports. Detailed supporting data were presented in the quarterly reports for CY 1987 described above.

## 300 AREA PROCESS TRENCHES

R. Schalla

Major activities of the interim-status RCRA assessment-level ground-water monitoring project for the 300 Area Process Trenches completed during 1987 include the following:

- construction and testing of 18 new monitoring wells
- measurement of water levels for 50 wells
- continuous water-level measurements in eight wells and one surface-water station
- refinement of the conceptual hydrogeologic model of the study area using new data
- development of a transient simulation model of ground-water flow
- determination of concentrations of contaminants above maximum contaminant levels
- determination of the extent of migration of contaminants and, where possible, pathways and sources of several contaminants above maximum contaminant levels.



### WATER-LEVEL MEASUREMENTS

By March 1987, 19 new wells including 399-1-16D, which is not used as a monitoring well, had been added to the 31 older wells used to obtain water-level data (Figure 1). The network of 50 wells for obtaining water levels each month is shown in water-level contour maps in Figures 2, 3, and 4, which indicate the approximate flow pattern for the shallow portion of the unconfined aquifer. The predominantly southeastern flow pattern in Figure 2 represents what may be the net annual pattern of ground-water flow in the 300 Area, and that flow is generally toward the Columbia River. Figures 3 and 4 illustrate seasonal variations caused by high and low river stages, respectively. Note that at high river stage, there is a strong component of flow from the river and southward through the 300 Area.

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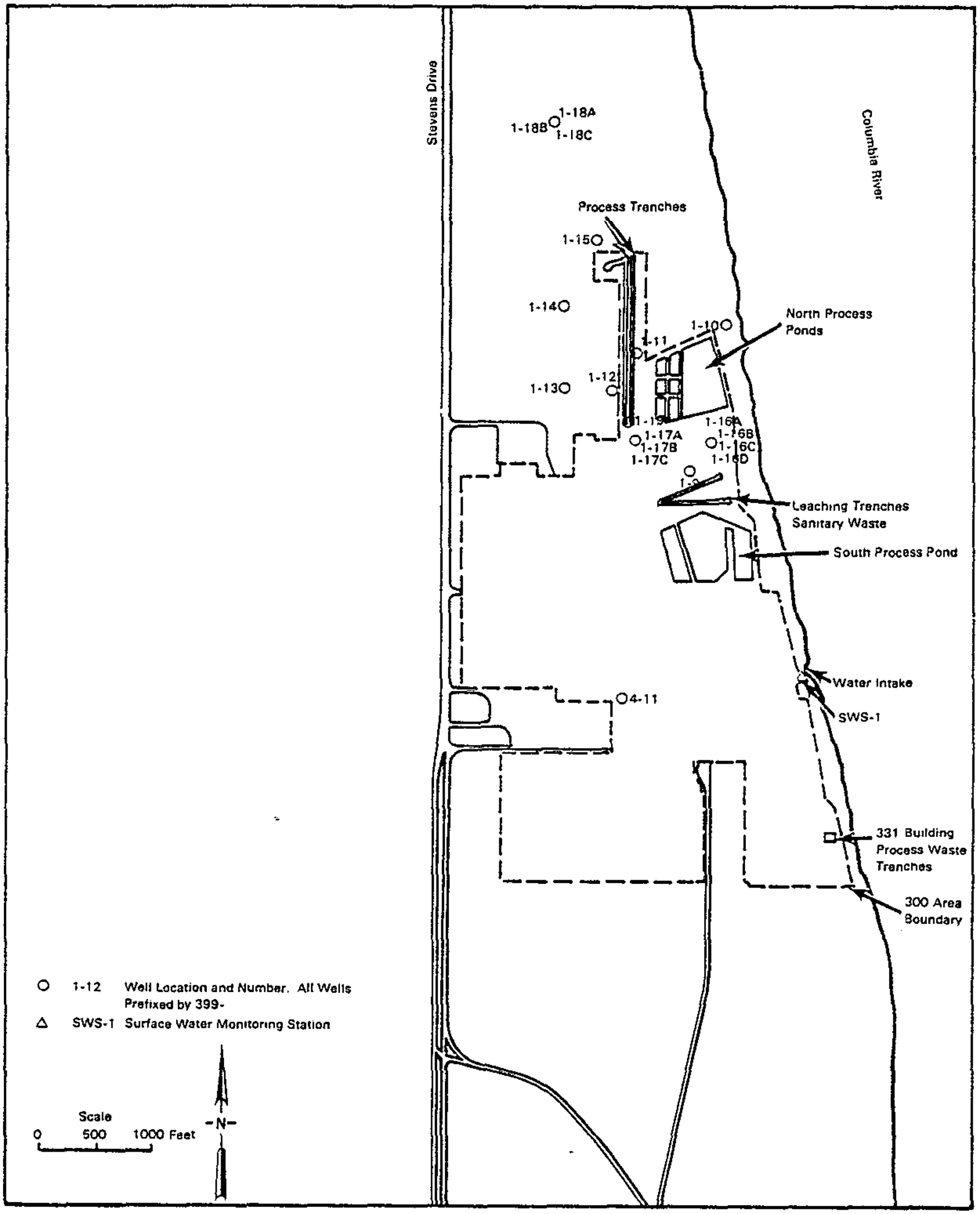


FIGURE 1. Location of the 19 New Wells in the 300 Area

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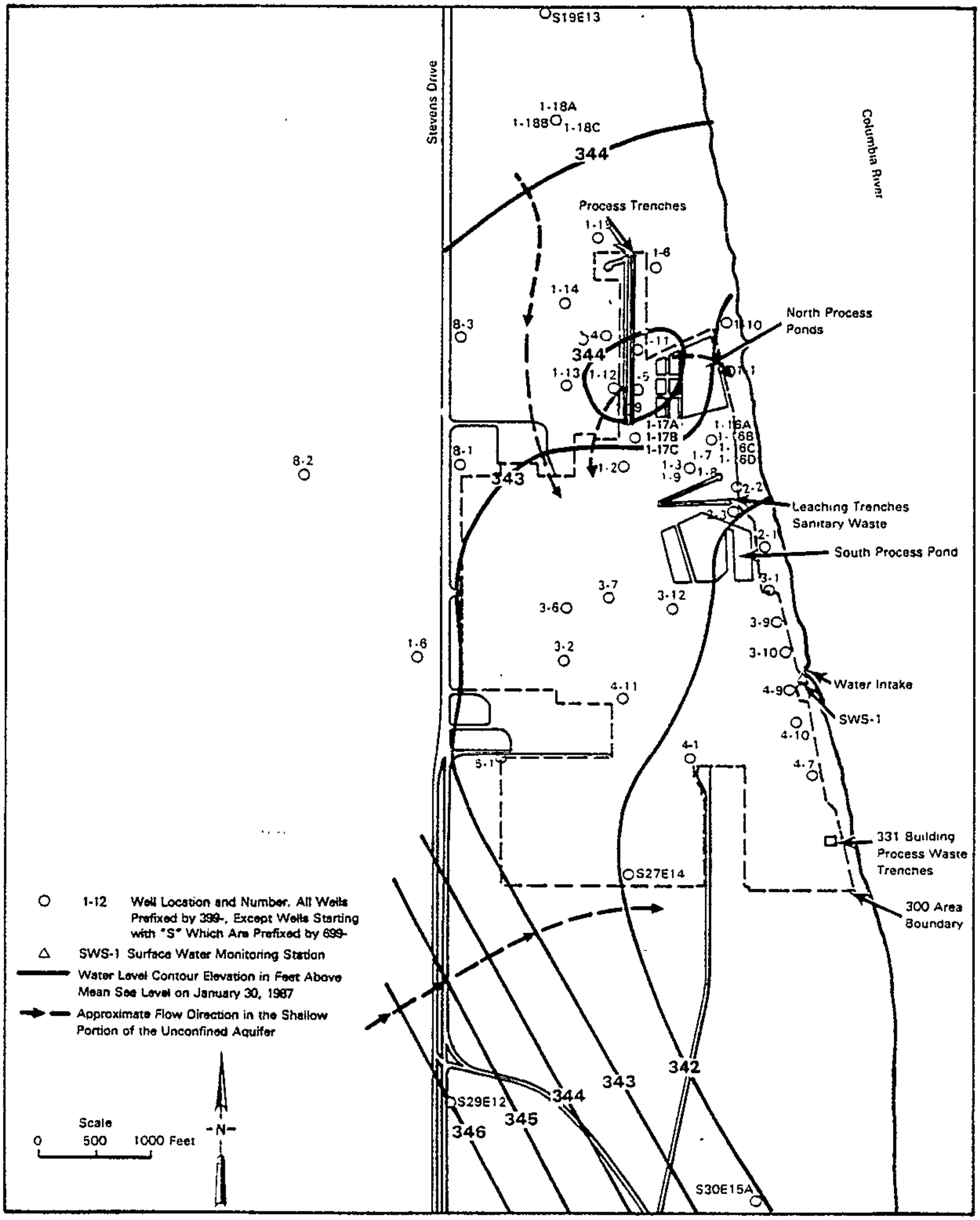


FIGURE 2. Typical Ground-Water Flow Pattern in the 300 Area

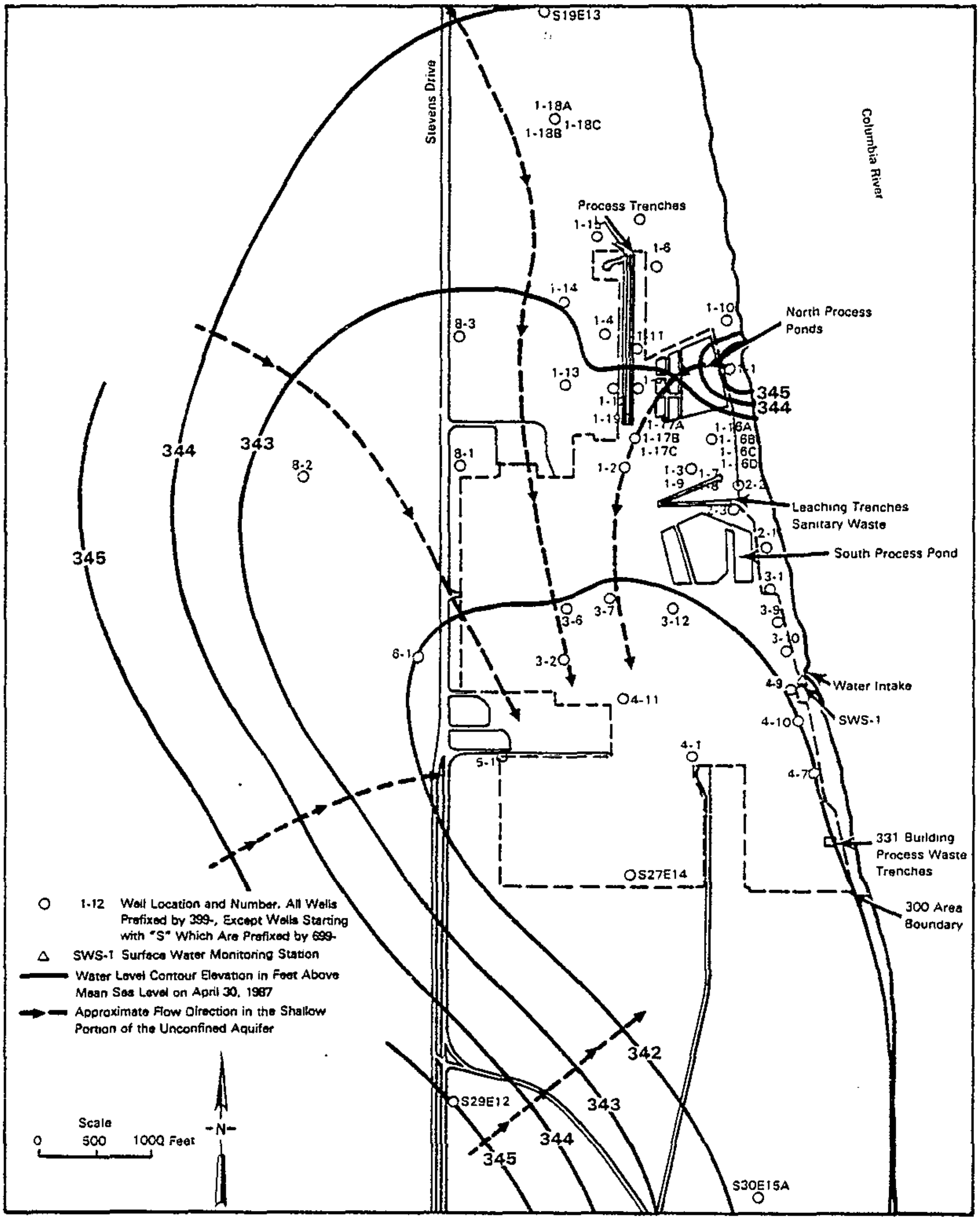


FIGURE 3. Ground-Water Flow Pattern for the 300 Area When the River Elevation is High

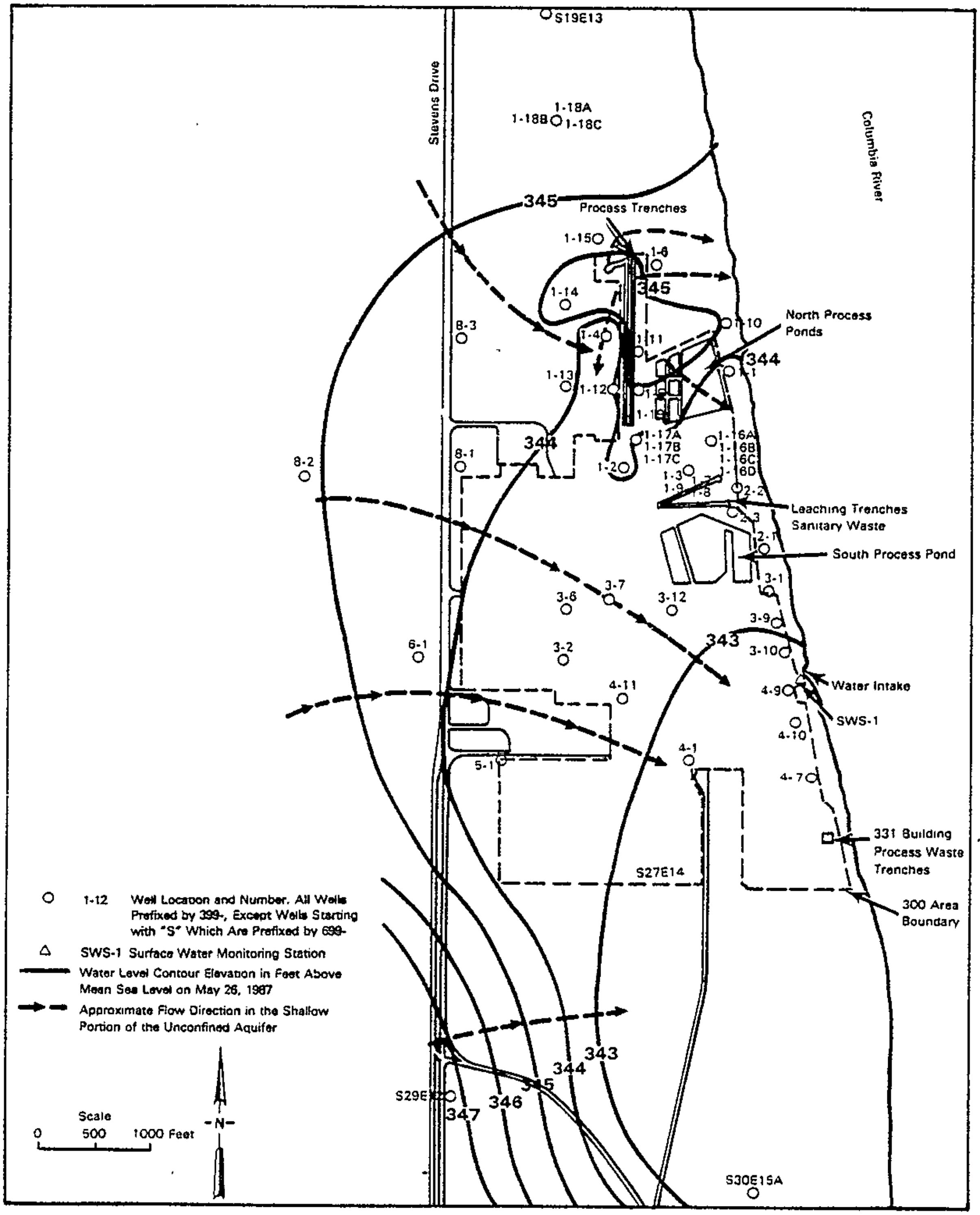


FIGURE 4. Ground-Water Flow Pattern for the 300 Area When the Ground-Water Gradient is Steep (river elevation is low)

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To evaluate the extent of that flow component and its influence on ground-water chemistry, electrical conductivity and temperature sensors were added to the data loggers in four wells (399-1-10, 399-1-16A, 399-1-17A, and 399-1-18A) near the river and process trenches. A temperature sensor was also added to well 399-1-4.

Following a review of geologic and hydrologic data, the cross section shown in Figure 5 was used to develop a three-dimensional ground-water flow model.

Initial and boundary condition files have been created for transient simulation of the ground-water flow system using the Coupled Fluid, Energy, and Solute Transport (CFEST) code (Gupta et al. 1982). The flow model has three layers: 1) the saturated (approximately 60-ft-thick) portion of the Hanford formation, 2) the upper portion of the Middle Ringold Formation (approximately 60 ft thick), and 3) the lower portion (approximately 10 ft thick) of the Middle Ringold Formation. Based on the continuous water-level data from the nine data loggers, time steps of 1 day are sufficient to account for changes in the ground-water levels in response to changing river stage. The results of the initial two-dimensional transient simulations also indicated that the hydraulic conductivity of layers 2 and 3 may be adequately represented by constant values, but the upper layer is better represented by at least two regions of differing hydraulic conductivity. The hydraulic conductivity distribution will be refined based on further data collection and model calibration.

A dramatic decline of 20 ft in the water level in well 399-1-16C was discovered between February (the month in which it was installed) and May 1987. This deep well is screened in the confined basal Ringold aquifer. No corresponding decline in water levels has been noted in the other deep wells. An unscheduled early June sampling was performed on well cluster 399-1-16. An examination of the ground-water chemistry data for well 399-1-16C from this early June sample shows the presence of constituents [(e.g., chloroform, 1,2-dichloroethene (1,2-DCE)] that had only been detected previously in shallow or intermediate wells screened in the unconfined aquifer. All intervals of the unconfined aquifer and the confined aquifer may be locally

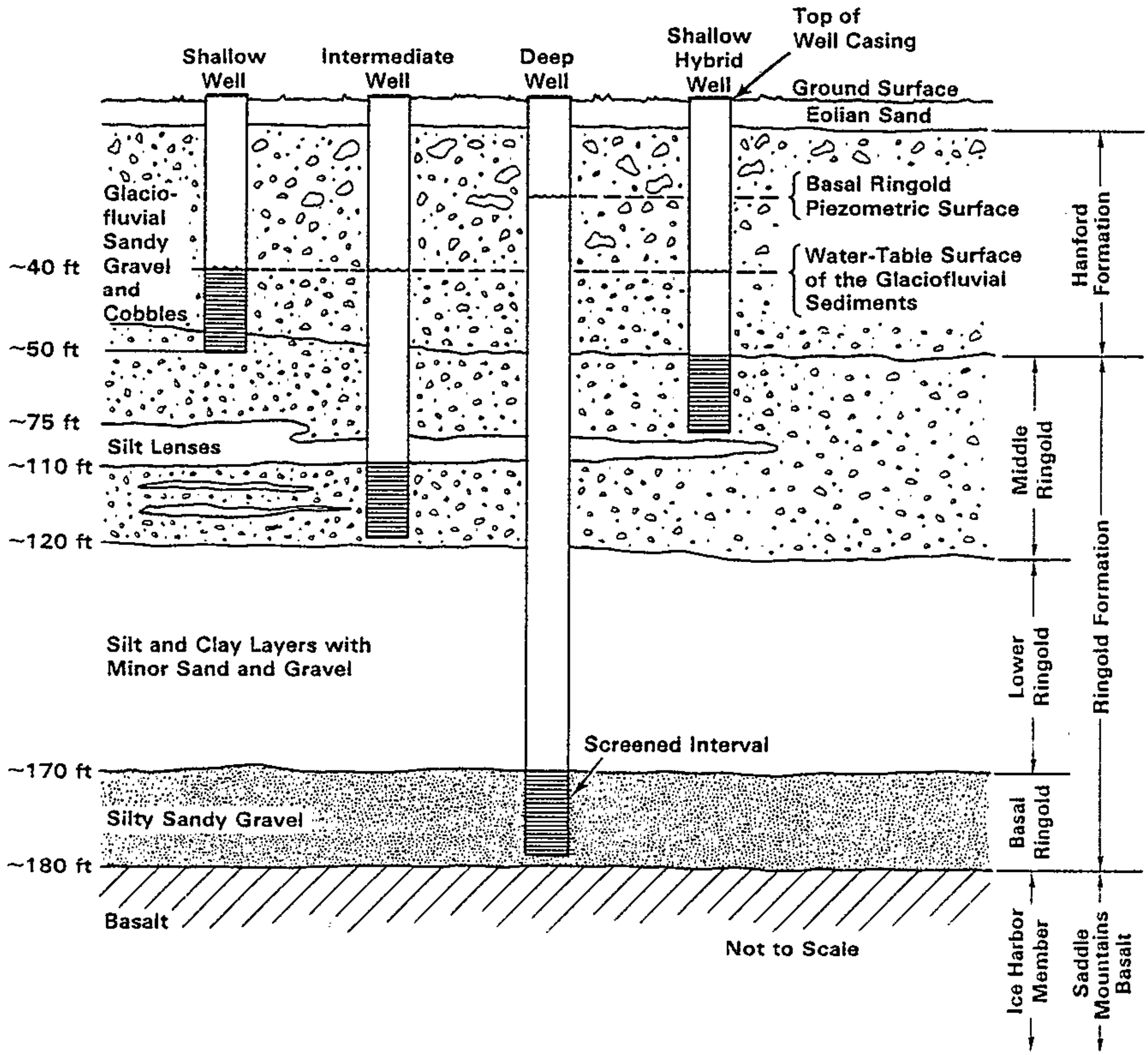


FIGURE 5. Types of Monitoring Wells and Schematic Cross Section

hydraulically interconnected as a result of inadequate sealing of adjacent well 399-1-16D. Alternative methods of well abandonment for regaining hydraulic isolation between the unconfined and confined aquifers in this area are being evaluated.

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CONTAMINANT CONCENTRATIONS ABOVE MAXIMUM CONTAMINANT LEVELS

By March 1987, 18 new monitoring wells (Figure 1) were added to the 16 older wells used to obtain water chemistry data. This network of 34 monitoring wells is shown in Figure 6. The ground water in the vicinity of the 300 Area process trenches has been sampled and analyzed monthly from June 1985 to April 1987, bimonthly from May to September 1987, and quarterly from October to December 1987.

In November, wells 399-1-3 and 399-1-5 were substituted with existing monitoring wells 399-8-1 and 399-8-3. This change provided for additional chemistry data on concentration gradients west of the process trenches and eliminated redundant water chemistry data that are already provided by wells 399-1-11 and 399-1-7.

Beginning in October, three wells (399-1-11, 399-1-17A, and 399-1-19) near the process trenches were sampled weekly for a limited set of specific constituents (i.e., volatile chlorinated hydrocarbons, metals for 2 months, then anions and uranium).

Gross alpha levels reported in February for several wells increased from the previous month. These increases appear to be in response to cleaning operations in the inlet weir to the process trenches, which began in mid-February and lasted for approximately 2 weeks. Approximately 600 kg of uranium were recovered from material taken from the weir. All wells near the trenches, except wells 399-1-4 and 399-1-6 that were sampled before initiation of the cleaning operations, showed increases in gross alpha. The gross alpha levels in all these wells were greater than the 15-pCi/L drinking water standard. Three of the new wells adjacent to the trenches, which were first sampled in February (i.e., wells 399-1-11, 399-1-12, and 399-1-17A), showed gross alpha levels greater than the drinking water standard. Well 399-1-17A had a reported gross alpha concentration of 156 pCi/L. Later, downgradient wells farther from the trenches showed gross alpha levels higher than those previously reported, but concentrations in fewer than half were over the drinking water standard. Gross alpha levels in intermediate and deep wells remained below detection limits.

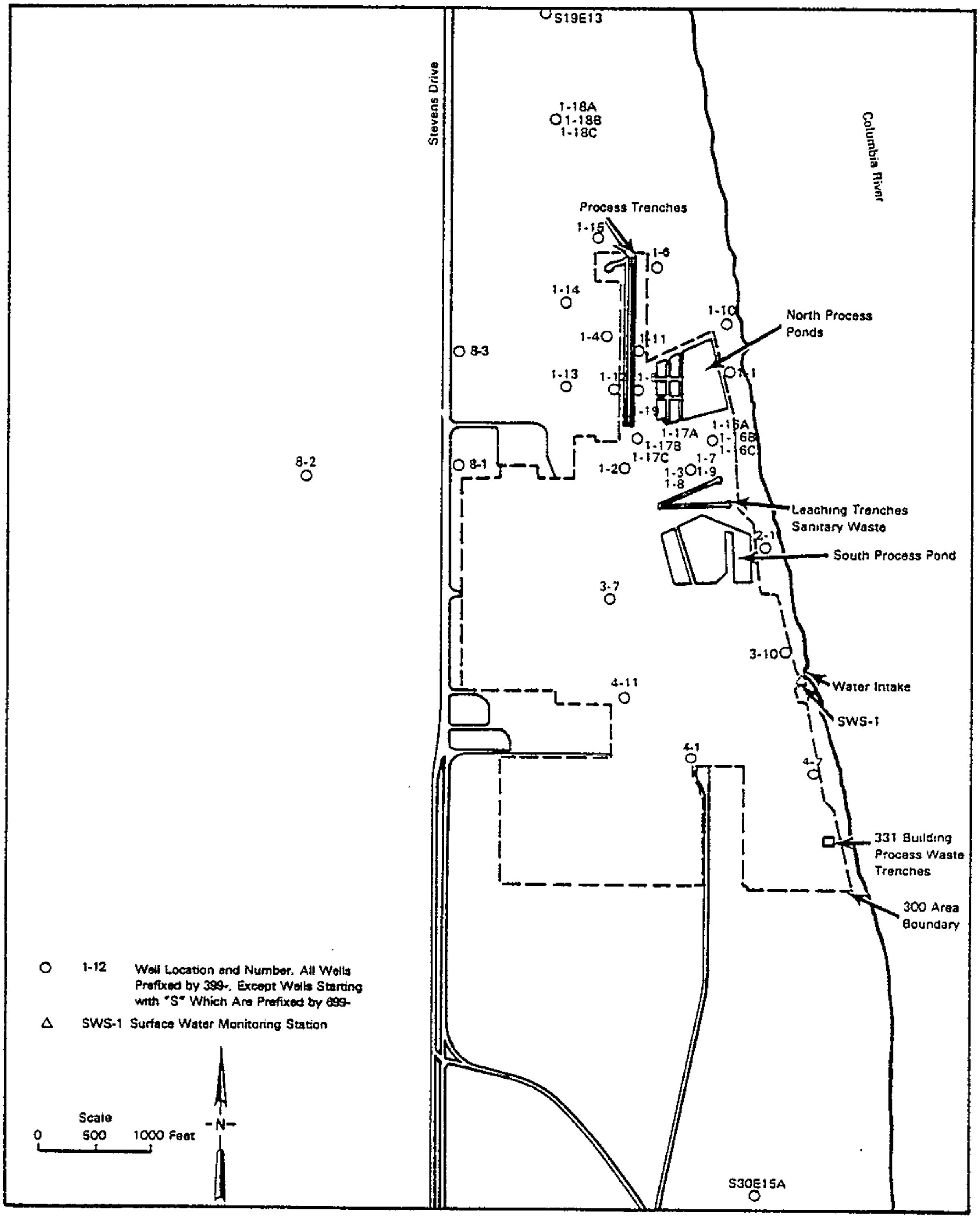


FIGURE 6. Water Chemistry Monitoring Well Locations for the 300 Area

Samples collected in November from all wells in the monitoring network were analyzed for uranium. In addition, samples from wells 399-1-11, 399-1-17A, and 399-1-19 were collected weekly and analyzed for uranium during October, November, and December. The results of these analyses ranged from less than the analytical detection limit (0.5 pCi/L) to 307 pCi/L in the November 30 sample from well 399-1-19. Concentrations in shallow wells screened in the top of the unconfined aquifer decreased downgradient, and concentrations in upgradient wells 399-1-18A, 399-8-1, 399-8-2, 399-8-3, and 699-S19-E13 were low, ranging from 1.3 pCi/L in 699-S19-E13 to 3.6 pCi/L in 399-8-3. Uranium concentrations in the intermediate (i.e., bottom of the unconfined aquifer) and deep (i.e., screened in the confined aquifer) wells 399-1-18B and 399-1-18C upgradient from the trenches were less than the detection limit. The uranium concentrations and gross alpha activities reported for samples that were analyzed for both constituents are in close agreement, indicating that uranium is the primary alpha-emitting radionuclide in the samples. Uranium, which must be excluded from the alpha count to determine whether the drinking water standard has been exceeded, represents most of the alpha activity. Therefore, alpha activity does not actually exceed the drinking water standard for 300 Area wells.

The volatile organics detected in concentrations greater than the detection limit were trichloroethylene (TCE); 1,2-DCE; perchloroethylene (PCE); 1,1,1-trichloroethane (1,1,1-T); chloroform; methylene chloride; and methyl ethyl ketone (MEK). Of these, only TCE and 1,2-DCE had concentrations greater than their U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL).

Trichloroethylene, with an MCL of 5 ppb, had recently measured concentrations of 21 and 6 ppb in wells 399-1-16B and 399-4-11, respectively. In well 399-1-16B, which was first reported in March at 20 ppb, TCE has fluctuated within 10% of that value throughout the year. Concentrations of TCE in well 399-4-11 before October were below detection limits. A few downgradient wells, particularly those screened in the bottom of the unconfined aquifer or near the process trenches, had detectable TCE concentrations that were below 5 ppb.

A degradation isomer of TCE, 1,2-DCE, has been detected consistently in samples from intermediate wells 399-1-16B and 399-1-17B. The MCL for 1,2-DCE is 70 ppb. Concentrations of 1,2-DCE in intermediate wells 399-1-16B and 399-1-17B have remained essentially unchanged. The concentration of 1,2-DCE in well 399-1-16B has fluctuated with no apparent trend between a minimum of 63 ppb and a maximum of 72 ppb, and concentration in well 399-1-17B has varied between 26 and 31 ppb. Currently, the concentrations of 1,2-DCE are below the MCL in both wells. Samples from neither well 399-1-16A, 399-1-17A, nor any other shallow wells have shown 1,2-DCE to be present above detection limits.

The concentrations of fluoride in intermediate to deep wells 399-1-9, 399-1-16B, 399-1-16C, 399-1-17B, 399-1-17C, 399-1-18B, and 399-1-18C continue to be greater than the detection limit (500 ppb) and near or above the drinking water standard. The primary drinking water standard for fluoride is 4000 ppb. Fluoride concentrations above detection limits were reported for several shallow wells near the process trenches.



EXTENT AND RATE OF MIGRATION

The concentration of uranium for November is highest in wells immediately adjacent to the trenches (Figure 7). This figure is supplemented by some uranium data from wells sampled in October as part of the site-wide Hanford Ground-Water Monitoring Project. The variable but continuous release rate from the trenches, coupled with the variable flow direction and high ground-water velocity (i.e., several feet to several tens of feet per day) in the shallow portion of the unconfined aquifer, results in variations in the concentration gradient, extent, and shape of the uranium plume.

The extent and source of TCE and 1,2-DCE at the bottom of the unconfined aquifer are unknown because only three wells are screened in the bottom of the unconfined aquifer. The consistency of the values suggests that either a nonaqueous source is nearby, or the ground-water flow velocities at the bottom of the confined aquifer are much slower than those at the top of the aquifer. The presence of TCE and 1,2-DCE in well 399-1-16B is of particular concern because of the observed hydraulic interconnection between the

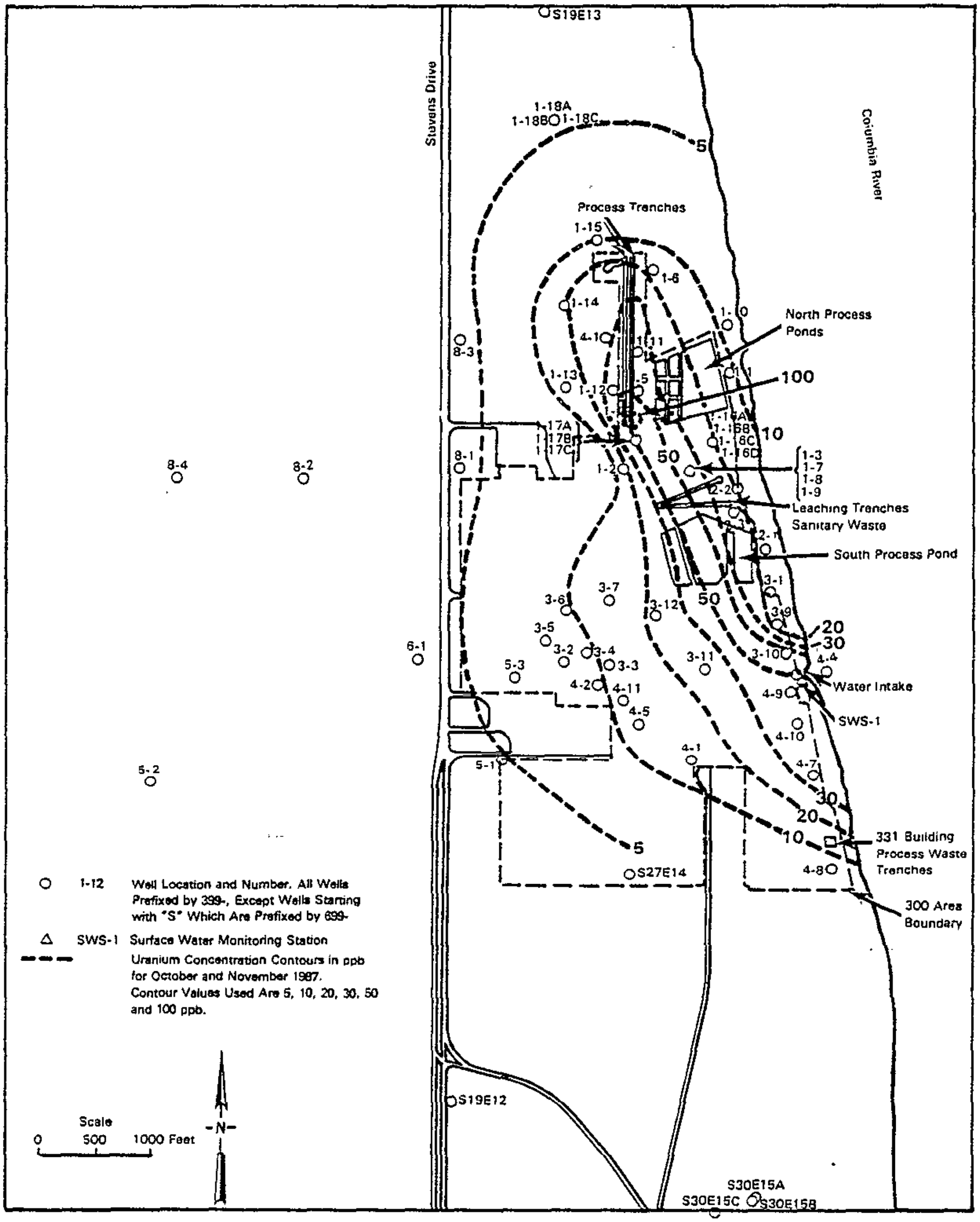


FIGURE 7. Uranium Concentrations in 300 Area Monitoring Wells During October and November 1987

9 2 1 2 5 4 1 0 6 3 7

confined basal Ringold and unconfined aquifers near this well. The groundwater chemistry data from the special early June sampling of well 399-1-16C showed the presence of 1,2-DCE, which had previously only been detected in intermediate wells screened in the bottom of the unconfined aquifer. The early sampling data for June also indicated the presence of low concentrations of chloroform in well 399-1-16C. Chloroform, which is produced during treatment (i.e., chlorination) of water taken from the river, has otherwise only been detected in shallow wells adjacent to and immediately downgradient from the process trenches. Both chloroform and 1,2-DCE were detected in well 399-1-16C, which is screened in the confined basal Ringold aquifer. All intervals of the local unconfined aquifer may be hydraulically interconnected as a result of inadequate sealing of well 399-1-16D. As a temporary measure to prevent induced flow of TCE and 1,2-DCE from the unconfined to the confined aquifer, purging of well 399-1-16C to obtain further samples of the water in the confined aquifer was limited to approximately 0.1 borehole volume.



Several related volatile organic constituents (PCE, TCE, and 1,2-DCE) were detected in the weekly sampling of three shallow wells with concentrations of all constituents decreasing to their lowest concentrations by the end of November. The PCE concentration, which has no MCL, was 6 ppb in well 399-8-2 and similar concentrations in these three wells. Also, 1,1,1-T was detected in the weekly samplings at very low concentrations. The low concentrations of these compounds that originate from the process trenches could be a result of desorption from sediments from previously documented high-concentration releases in 1982 and 1984 (Cline, Rieger, and Raymond 1985) rather than as recent low-concentration releases.

For the most recent sampling, the highest concentrations for 1,1,1-T were found in well 399-8-2 at 19 ppb, which is well below the 200-ppb MCL. 1,1,1-trichloroethane in well 399-8-2 was reported in March to be 83 ppb, but was not detected in April.

Randomly distributed methylene chloride has been detected in one or two wells per sampling period at concentrations as high as 580 ppb, but based on historical experience, the importance and relevance of these few values as related to observed contaminant plumes are questionable.

Finally, MEK was detected in wells 399-1-13, 399-1-16A, 399-1-16B, 399-1-18A, 399-1-18B, and 399-1-18C in concentrations ranging from 11 ppb in well 399-1-16A to 45 ppb in well 399-1-18A. There is no MCL for MEK, and MEK has not been previously reported in any wells. Because these samples were all analyzed on the same day in the laboratory, UST was asked to review their laboratory data. Their conclusion was that the results were suspect because the reverse osmosis apparatus was repaired that day and open to the ambient air of the extraction laboratory. In addition, the blank water sample included with these samples had an MEK concentration of 64 ppb, higher than any of the other samples.

Based on data from intermediate wells (upper Middle Ringold), the lower portions of the unconfined aquifer (lower Middle Ringold) generally have a different water chemistry, lower transmissivity, and probably much slower ground-water velocities than the shallow portion of the unconfined aquifer (Hanford formation). Samples from the lower unconfined aquifer generally have concentrations of several constituents (i.e., ammonium, barium, chromium, fluoride, iron, manganese, potassium, sodium, and sulfate) that are significantly different from those in the shallow wells, except for well 399-1-19. For example, the concentrations of fluoride are consistently higher in all intermediate and deep wells regardless of their location relative to the process trenches. This suggests that the presence of these constituents in the lower portion of the unconfined aquifer and confined aquifer may be attributed to differences in the geochemistry of the aquifer and not to the presence of the process trenches.

In August the analytical results for metals in the unfiltered samples from well 399-3-7 had been higher than those for the filtered samples; however, in November the concentrations of the constituents in the filtered samples increased to levels similar to those detected in unfiltered samples. The analytical results for filtered and unfiltered samples from all other wells agree very closely for all metals except iron. Iron levels in unfiltered samples from many of the wells are higher than those in filtered samples. Iron concentrations above detection occur only in older wells that are not constructed of stainless steel. Based on the data collected this year, the presence of small amounts of iron in the water from older wells does not appear to have a significant influence on other inorganic compounds in the samples.

For the first time, the primary source and extent of uranium in ground water have been defined using a large number of wells. Historical data from a smaller number of wells indicate that there have been substantial concentration fluctuations in some wells, including wells that may be considered upgradient of the process trenches. Until additional data are collected and historical data completely evaluated, it will not be possible to determine if the process trenches are the only significant source of uranium contamination. The changes in the size, concentration, configuration, and rate of migration of the uranium plume will be described in subsequent reports.

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## 183-H SOLAR EVAPORATION BASINS

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Major activities of the interim-status RCRA assessment-level ground-water monitoring project for the 183-H Solar Evaporation Basins (183-H basins) completed during 1987 include the following:

- interim characterization report for the area surrounding the 183-H basins (PNL 1987e)
- Phase III expansion of the ground-water monitoring network
- aquifer testing of the Phase II wells
- remedial work on the five original monitoring wells
- planning and site surveying for a permanent river stage gaging station
- routine sampling of all wells.



### WATER-LEVEL MEASUREMENTS

With the addition of the Phase III wells (199-H4-16, 199-H4-17, and 199-H4-18), 25 wells are now located in the 100-H Area (Figure 8).. Of this total, well 199-H4-2 was used for geohydrologic characterization, well 199-H-15C was dedicated to hydraulic head measurements, and the remaining 23 wells comprise the 100-H Area sampling network.

Water levels were measured twice monthly using a graduated steel tape in the wells surrounding the 183-H basins. Continuous head measurements are collected with transducers in wells 199-H4-4 and 199-H4-5. The data were correlated with continuous river stage data from the Hanford Generating Project located at the 100-N Area. In Figure 9, changes in water-table elevation in all wells are compared to changes in river stage, and those wells located nearest the river show the greatest response.

A permanent river stage gaging station, as shown in Figure 10, will be installed at the 100-H Area. Continuous river stage data will be collected and correlated with the water-table measurements, and contaminant data to

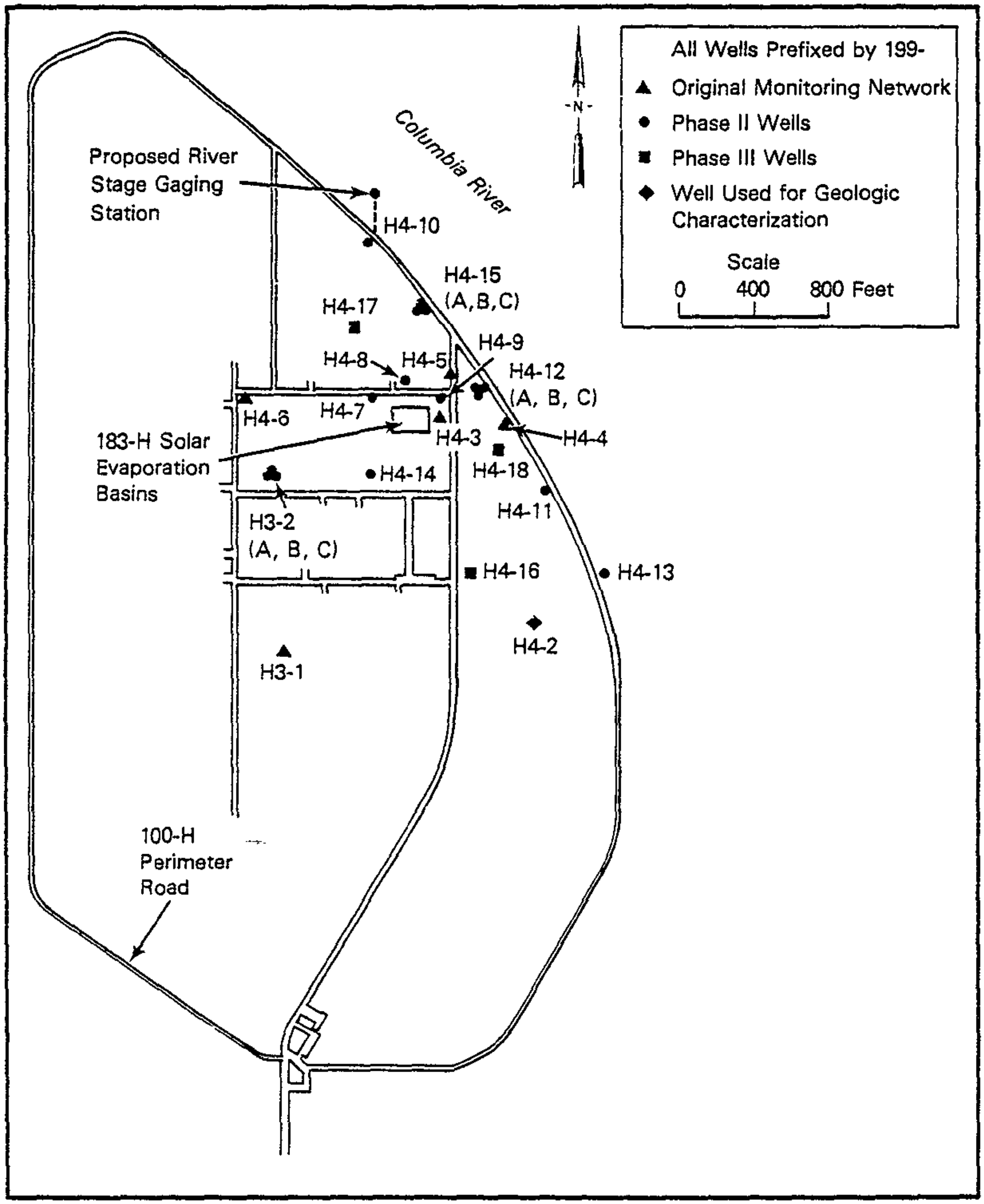


FIGURE 8. Monitoring Wells in the 100-H Area

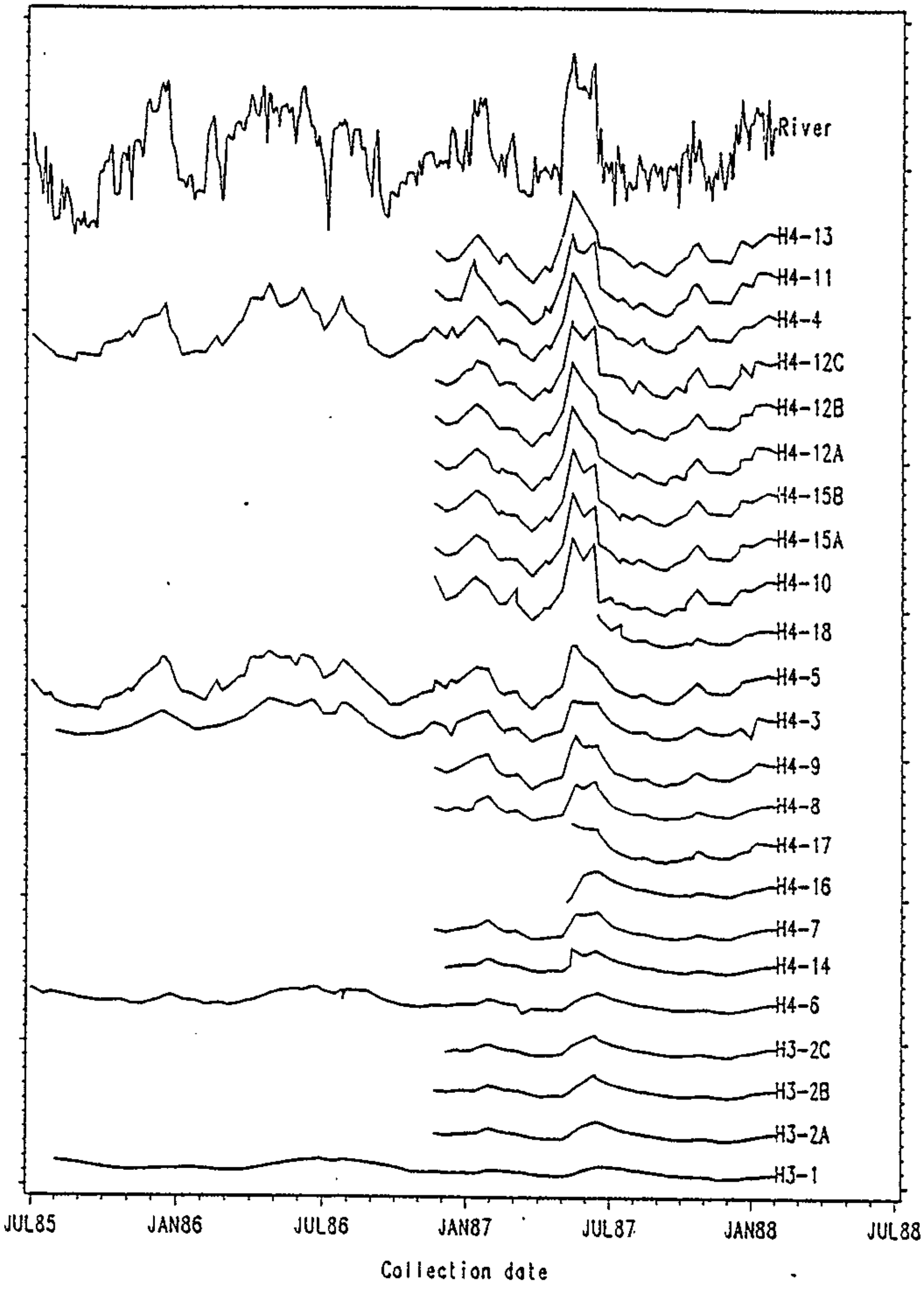


FIGURE 9. Relative Water Levels in the Columbia River and Monitoring Wells in the 183-H Solar Evaporation Basins. Vertical axis is marked in 1-ft increments for estimating fluctuations in individual wells, but not for comparing water levels between wells.

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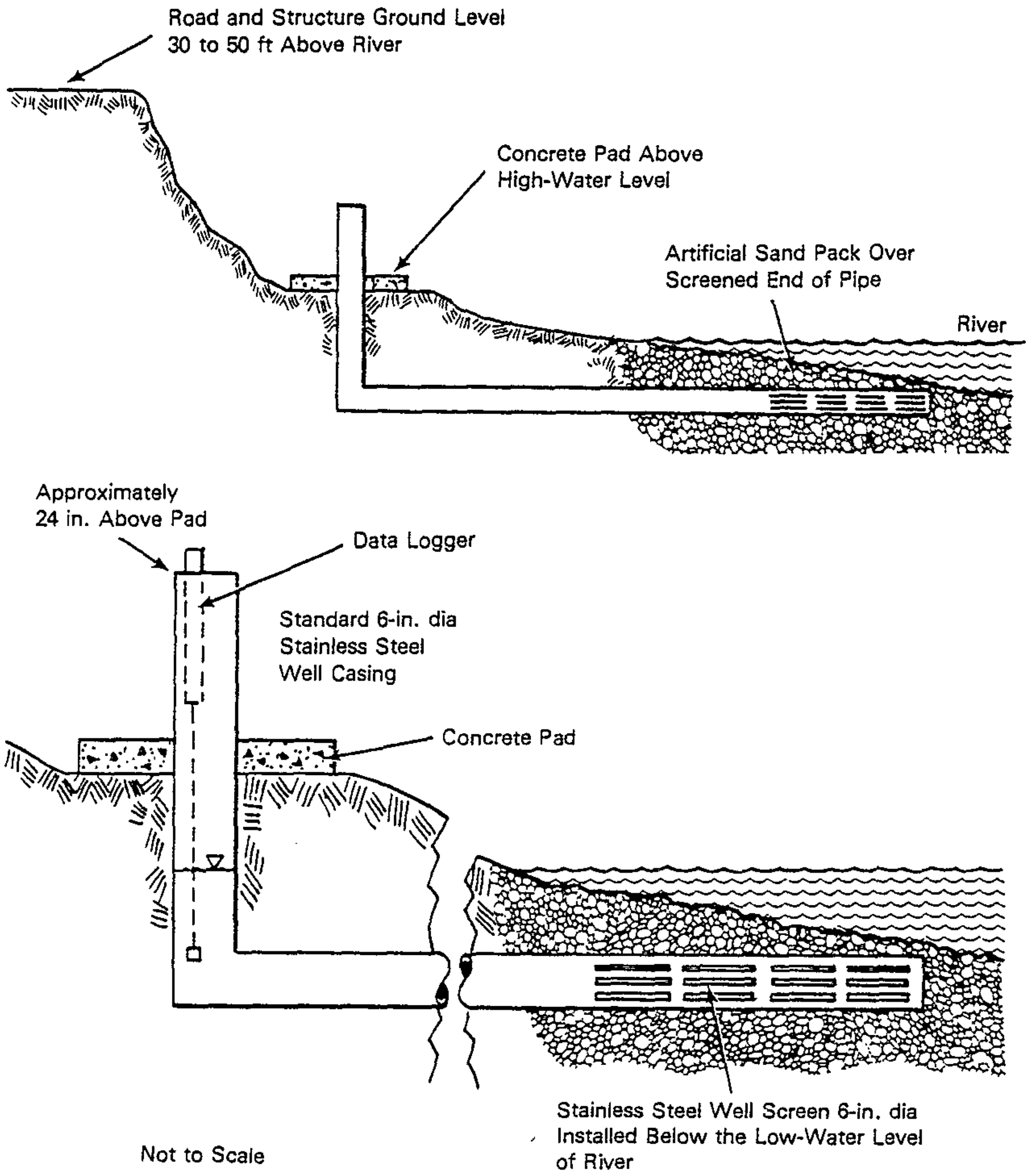


FIGURE 10. Proposed River Stage Gaging Station at the 100-H Area

improve modeling capabilities and refine estimated horizontal gradients. The proposed location for the gaging station is shown in Figure 8. The initial site survey, engineering drawings, and construction cost estimate are complete. Installation is planned for August 1988 provided that all the required permits are obtained.

Water-table maps for low (September 1987), mean (December 1986), and high (May 1987) Columbia River stages for the period September 1986 through September 1987 are shown in Figures 11, 12, and 13. As indicated in these figures, ground-water flow is generally northeast and east toward the river. The highest water-table gradient, 0.0008 ft/ft (see Figure 11), occurs during low river stage, and conversely, the lowest gradient, 0.0005 ft/ft (Figure 13), occurs at the high river stage. During periods of high stage, such as depicted in Figure 13, the hydraulic gradient to the river is reversed temporarily as far inland as the 183-H basins as water from the Columbia River infiltrates the unconfined aquifer as bank storage. Tables 1 through 3 list the measurements used to construct these water-table maps.



Hydrographs for the three well-cluster locations are shown in Figures 14, 15, and 16. Each cluster is composed of three wells screened at selected intervals within the Hanford, Ringold, and Saddle Mountains Basalt formations. The hydrographs for wells 199-H3-2A, 199-H3-2B, and 199-H3-2C are shown in Figure 14. Wells 199-H3-2A and 199-H3-2B are completed in the Hanford formation, and well 199-H3-2C is completed in the uppermost hydrostratigraphic unit of the Ringold Formation. The water-level elevations of these wells are nearly identical.

The hydrographs for wells 199-H4-12A, 199-H4-12B, and 199-H4-12C are shown in Figure 15. Wells 199-H4-12A and 199-H4-12B are completed in the Hanford formation, and well 199-H4-12C is completed in the uppermost hydrostratigraphic unit of the Ringold Formation. The water-level elevations in these wells are nearly identical.

The hydrographs for wells 199-H4-15A, 199-H4-15B, and 199-H4-15C are shown in Figure 16. Wells 199-H4-15A and 199-H4-15B are completed in the Hanford formation. Well 199-H4-15C contains four 2-in. piezometers (P, Q, R, S) completed at progressively shallower intervals, respectively, in the

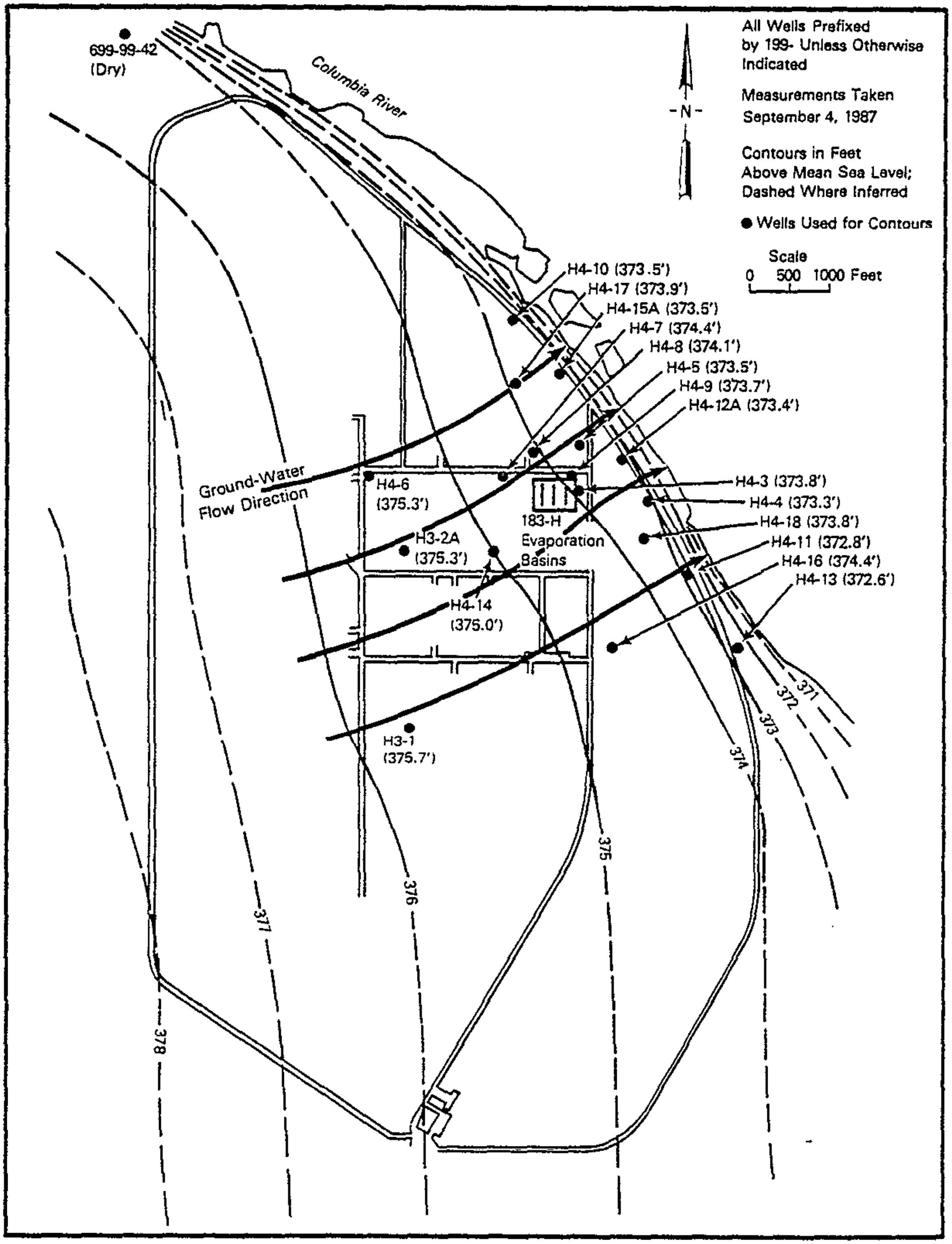


FIGURE 11. Water-Table Map Corresponding to Low Columbia River Stage

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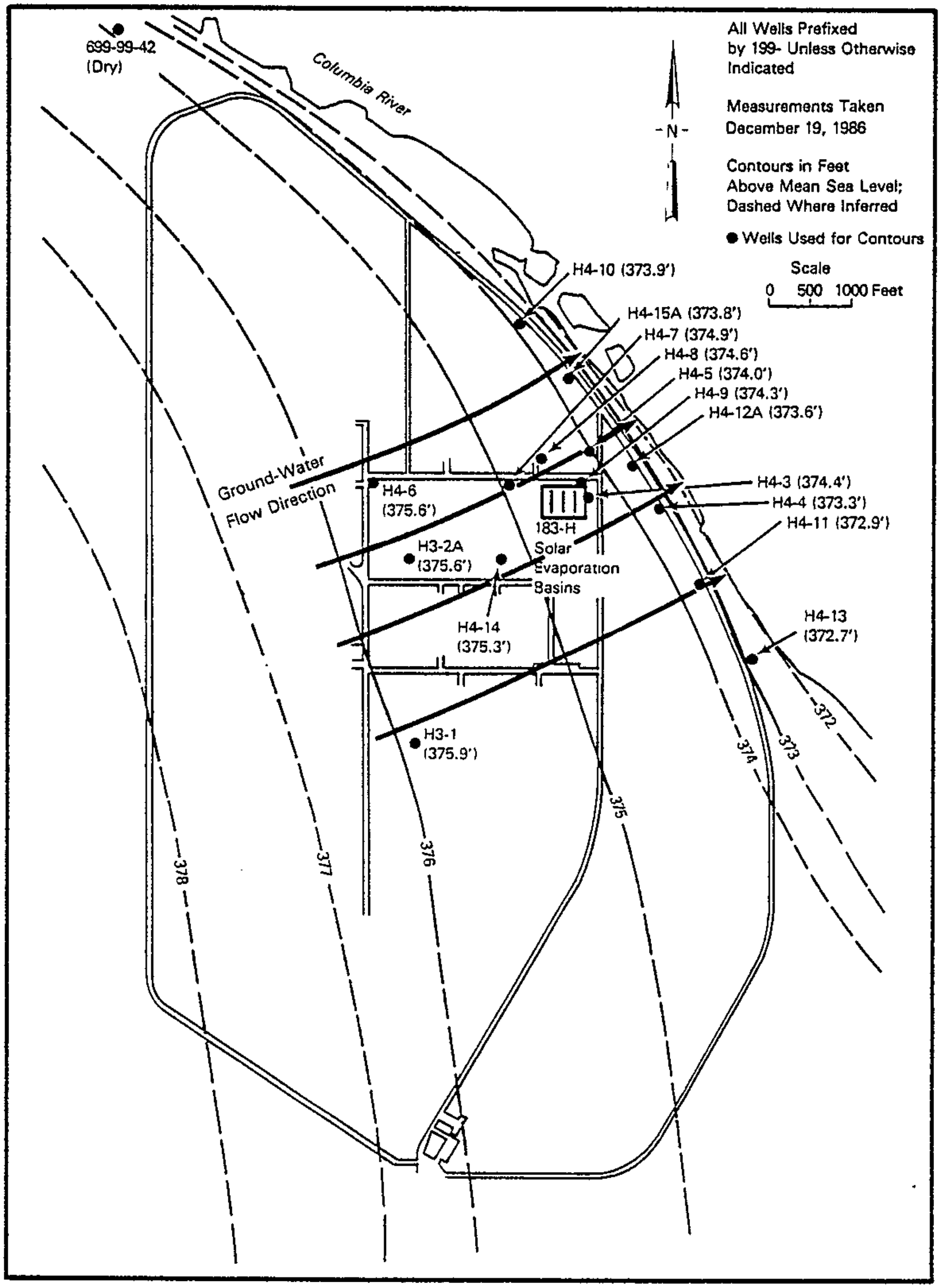


FIGURE 12. Water-Table Map Corresponding to Mean Columbia River Stage

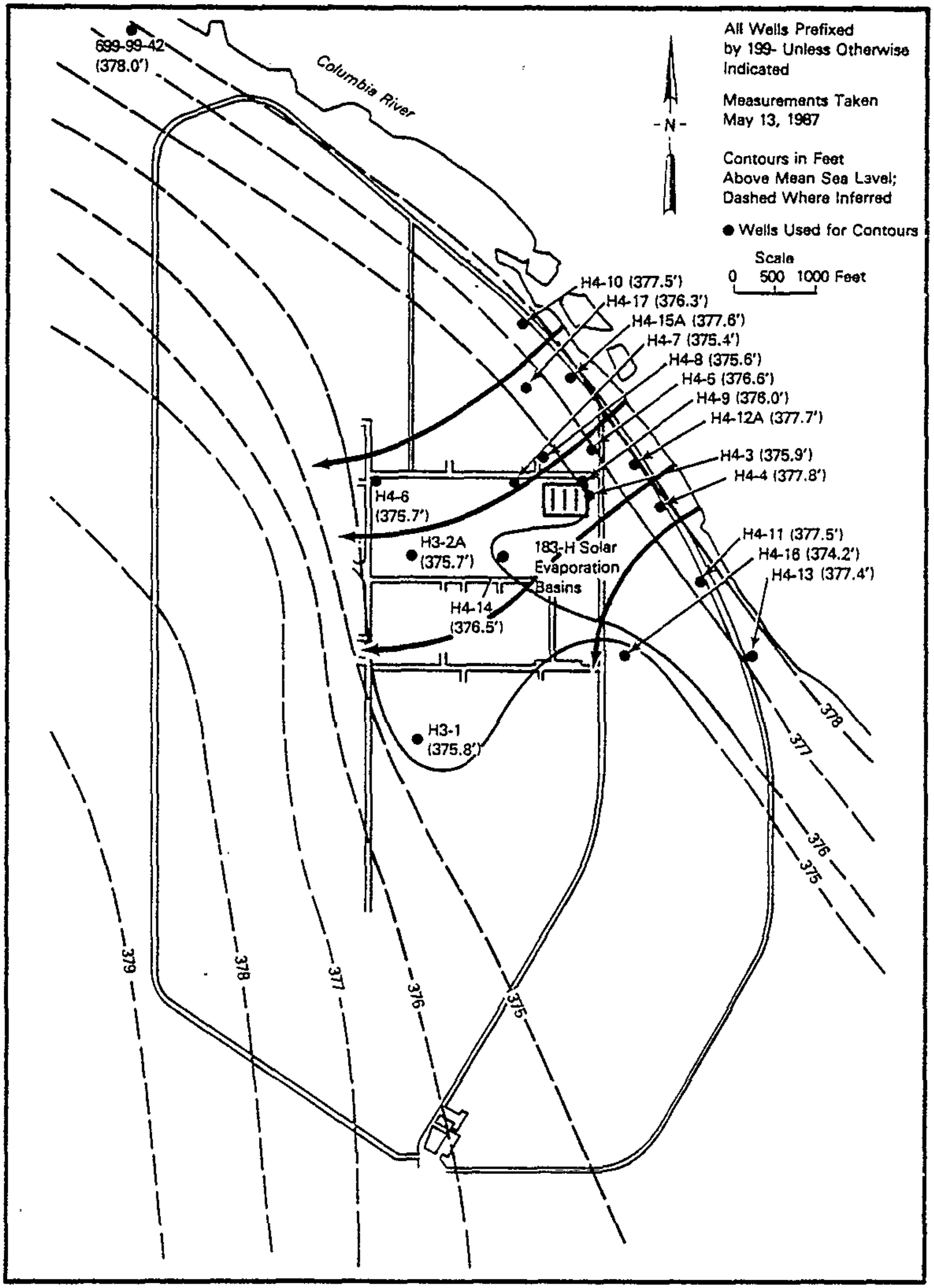


FIGURE 13. Water-Table Map Corresponding to High Columbia River Stage



9 2 1 2 6 4 1 0 6 9 8

TABLE 1. Water-Level Measurements for September 4, 1987 (Low Columbia River Elevation)

| Time (PST) | Well Number | Top of Casing Elevation (ft above MSL) | Depth to Water (ft) | Water-Level Elevation (ft above MSL) |
|---|---|---|---|---|
| 0853 | 699-88-41 | 416.04 | 33.53 | 382.51 |
| 0903 | 699-90-45 | 422.15 | 37.22 | 384.93 |
| 0912 | 699-91-37 | 422.93 | 50.12 | 372.81 |
| 0916 | 699-89-35 | 397.46 | 26.94 | 370.52 |
| 0920 | 699-90-34 | 392.39 | DRY | --- |
| 0934 | 199-H4-13 | 418.20 | 45.56 | 372.64 |
| 0938 | 199-H4-11 | 416.84 | 44.01 | 372.83 |
| 0946 | 199-H4-4 | 413.76 | 40.50 | 373.26 |
| 0950 | 199-H4-12A | 413.50 | 40.15 | 373.35 |
| 1002 | 199-H4-3 | 420.35 | 46.59 | 373.76 |
| 1008 | 199-H4-5 | 416.26 | 42.79 | 373.47 |
| 1013 | 199-H4-9 | 418.08 | 44.39 | 373.69 |
| 1018 | 199-H4-8 | 420.00 | 45.95 | 374.05 |
| 1022 | 199-H4-17 | 419.09 | 45.21 | 373.88 |
| 1026 | 199-H4-7 | 420.59 | 46.17 | 374.42 |
| 1031 | 199-H4-6 | 419.58 | 44.25 | 375.33 |
| 1035 | 199-H3-1 | 421.48 | 45.79 | 375.69 |
| 1101 | 199-H3-2A | 417.83 | 42.50 | 375.33 |
| 1105 | 199-H4-14 | 420.59 | 45.60 | 374.99 |
| 1111 | 199-H4-15A | 407.21 | 33.72 | 373.49 |
| 1131 | 199-H4-10 | 404.44 | 30.90 | 373.54 |
| 1134 | 699-99-42 | 412.88 | DRY | --- |
| 1141 | 699-97-43 | 421.81 | 42.99 | 378.82 |
| 1149 | 199-H4-18 | 421.82 | 47.98 | 373.84 |
| 1154 | 199-H4-16 | 424.23 | 49.84 | 374.39 |

TABLE 2. Water-Level Measurements for December 19, 1986 (Average Columbia River Elevation)

| Time (PST) | Well Number | Top of Casing Elevation (ft above MSL) | Depth to Water (ft) | Water-Level Elevation (ft above MSL) |
|---|---|---|---|---|
| 1140 | 699-88-41 | 416.04 | 33.44 | 382.60 |
| 1152 | 699-90-45 | 422.15 | 37.15 | 385.00 |
| 1202 | 699-91-37 | 422.93 | 49.92 | 373.01 |
| 1210 | 699-89-35 | 397.46 | 26.81 | 370.65 |
| 1216 | 699-90-34 | 392.39 | DRY | --- |
| 1301 | 199-H4-13 | 418.20 | 45.52 | 372.68 |
| 1309 | 199-H4-11 | 416.84 | 43.91 | 372.93 |
| 1316 | 199-H4-4 | 413.76 | 40.45 | 373.31 |
| 1322 | 199-H4-12A | 413.50 | 39.91 | 373.59 |
| 1346 | 199-H4-3 | 420.35 | 45.98 | 374.37 |
| 1353 | 199-H4-5 | 416.26 | 42.25 | 374.01 |
| 1358 | 199-H4-9 | 418.08 | 43.80 | 374.28 |
| 1405 | 199-H4-8 | 420.00 | 45.44 | 374.56 |
| 1414 | 199-H4-7 | 420.59 | 45.72 | 374.87 |
| 1423 | 199-H4-6 | 419.58 | 43.98 | 375.60 |
| 1433 | 199-H3-1 | 421.48 | 45.56 | 375.92 |
| 1441 | 199-H3-2A | 417.83 | 42.24 | 375.59 |
| 1457 | 199-H4-14 | 420.59 | 45.31 | 375.28 |
| 1507 | 199-H4-15A | 407.21 | 33.46 | 373.75 |
| 1530 | 199-H4-10 | 404.44 | 30.52 | 373.92 |
| 1537 | 699-99-42 | 412.88 | DRY | --- |
| 1543 | 699-97-43 | 421.81 | 42.78 | 379.03 |

TABLE 3. Water-Level Measurements for May 13, 1987
(High Columbia River Elevation)

| Time (PST) | Well Number | Top of Casing Elevation (ft above MSL) | Depth to Water (ft) | Water-Level Elevation (ft above MSL) |
|---|---|---|---|---|
| 0809 | 699-88-41 | 416.04 | 33.49 | 382.55 |
| 0822 | 699-90-45 | 422.15 | 37.19 | 384.96 |
| 0836 | 699-91-37 | 422.93 | 49.64 | 373.29 |
| 0844 | 699-89-35 | 397.46 | 24.39 | 373.07 |
| 0858 | 199-H4-13 | 418.20 | 40.35 | 377.35 |
| 0904 | 199-H4-11 | 416.84 | 39.39 | 377.45 |
| 0912 | 199-H4-4 | 413.76 | 36.01 | 377.75 |
| 0921 | 199-H4-3 | 420.35 | 44.45 | 375.90 |
| 0932 | 199-H4-5 | 416.26 | 39.65 | 376.61 |
| 0939 | 199-H4-12A | 413.50 | 35.78 | 377.72 |
| 1026 | 199-H4-9 | 418.08 | 42.11 | 375.97 |
| 1035 | 199-H4-8 | 420.00 | 44.42 | 375.58 |
| 1044 | 199-H4-17 | 419.09 | 42.79 | 376.30 |
| 1051 | 199-H4-7 | 420.59 | 45.13 | 375.44 |
| 1105 | 199-H4-6 | 419.58 | 43.90 | 375.68 |
| 1113 | 199-H3-1 | 421.48 | 45.66 | 375.82 |
| 1137 | 199-H3-2A | 417.83 | 42.17 | 375.66 |
| 1148 | 199-H4-14 | 420.59 | 44.07 | 376.52 |
| 1200 | 199-H4-15A | 407.21 | 29.64 | 377.57 |
| 1236 | 199-H4-10 | 404.44 | 26.90 | 377.54 |
| 1247 | 699-99-42 | 412.88 | 34.88 | 378.00 |
| 1255 | 699-97-43 | 421.81 | 42.90 | 378.91 |
| 1330 | 199-H4-16 | 424.23 | 50.07 | 374.16 |

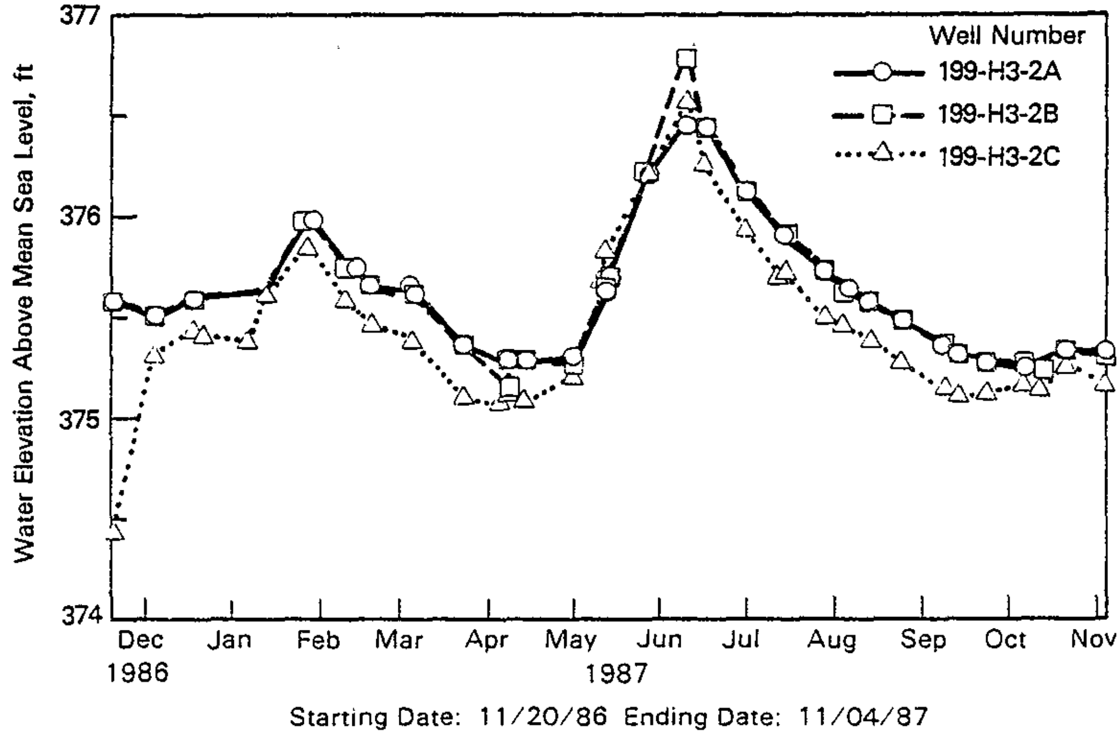


FIGURE 14. Hydrographs for Wells 199-H3-2A, 199-H3-2B, and 199-H3-2C

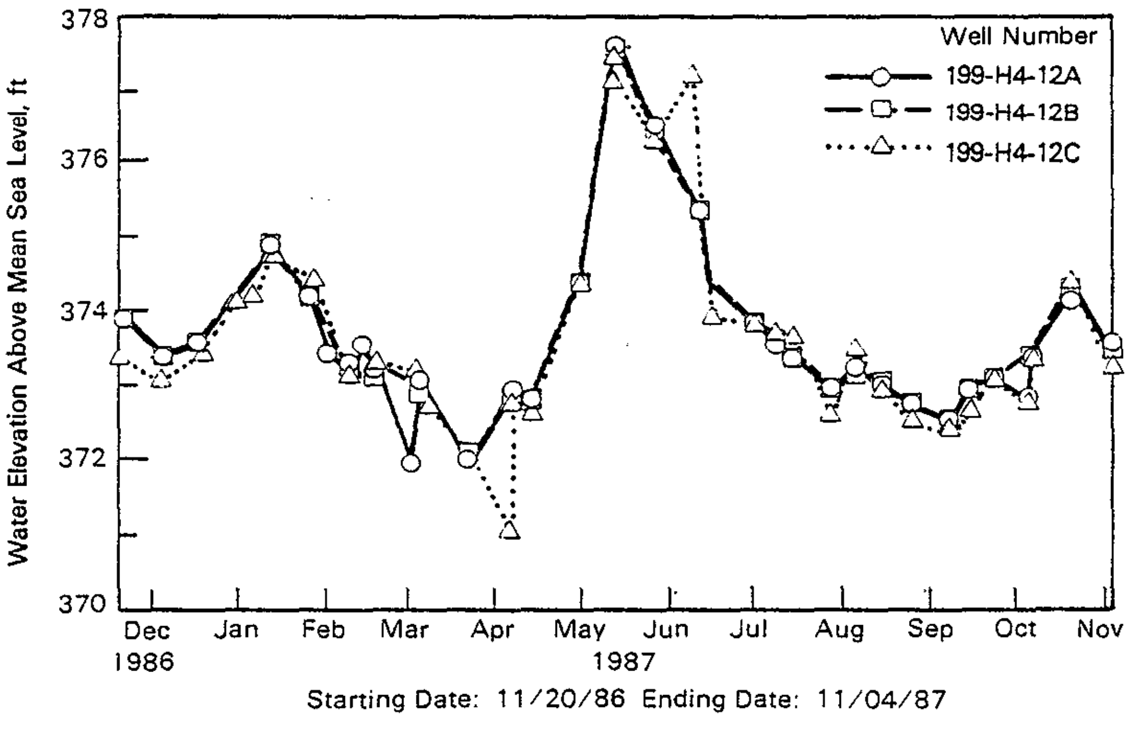


FIGURE 15. Hydrographs for Wells 199-H4-12A, 199-H4-12B, and 199-H4-12C

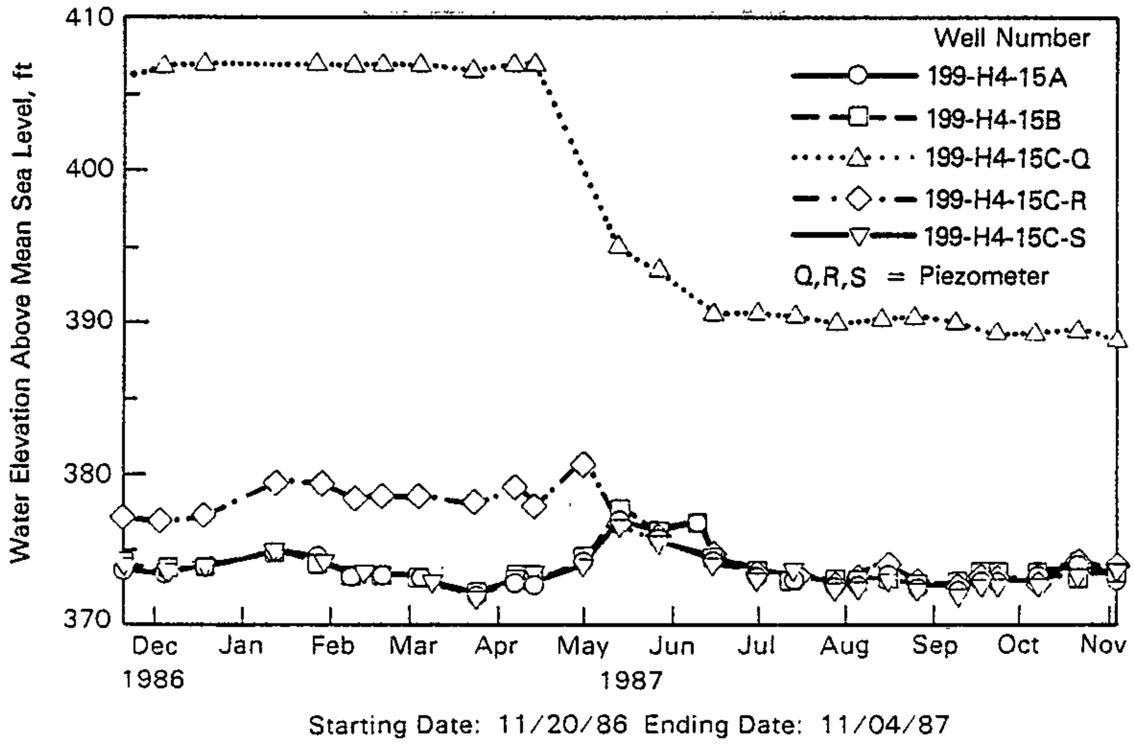


FIGURE 16. Hydrographs for Wells 199-H4-15A, 199-H4-15B, and 199-H4-15C



hydrostratigraphic units of the Ringold and Saddle Mountains Basalt formations. The water-level elevations in the two uppermost wells and piezometer S are nearly identical. Piezometer P, located at approximately 420 ft above mean sea level, has been capped to prevent it from flowing at the surface and is not shown in Figure 16.

The hydrographs in Figure 16 indicate that piezometers Q and R have lost 15 and 3 ft, respectively, of hydraulic head. Piezometer R has reached equilibrium with the uppermost wells. Testing of piezometers Q and R in May 1987 appears to have altered the integrity of the bentonite seals above their screened intervals. The removal of cloudy water during testing, possibly the bentonite, at the surface was assumed to be a result of well development. Both the large vertical separation (99 ft) and the seal between these screened intervals were thought to have provided sufficient protection from hydraulic interconnection before testing. The efficiency of the seals around the piezometers may increase with time as the silty clayey sand to sandy silty clay, and silty sand units settle through lithostatic pressure. Observation of the piezometer for several years may be necessary to determine if isolation of screen intervals has been restored. Because the threat of contaminating the lower aquifers is very low, it is not deemed practical to remediate or refill this well.

## CONTAMINANT CONCENTRATIONS ABOVE MAXIMUM CONTAMINANT LEVELS

As mentioned previously, the 100-H Area sampling network is composed of 23 wells. Ground-water monitoring for hazardous constituents was initiated in June 1985 and continued monthly through September 1987. At that time, sampling for wells 199-H3-1, 199-H4-5, and 199-H4-6 was reduced to quarterly, because these wells are located outside the contaminant plume attributable to the 183-H basins.

During 1987, five constituents were reported above the primary drinking water standards. These included gross alpha (15 pCi/L), gross beta (50 pCi/L), filtered and nonfiltered chromium (50 ppb), coliform bacteria (1 mpn), and nitrate (45,000 ppb) (Table 4).

In general, elevated levels of gross alpha, gross beta, chromium, sodium, and nitrate are present in the contaminant plume attributed to the 183-H basins. Figures 17 through 21 show the concentrations of these constituents over time in the wells most affected by the facility during 1987. These wells include 199-H4-3, 199-H4-4, 199-H4-9, 199-H4-12A, 199-H4-12B, and 199-H4-12C.

## EXTENT AND RATE OF MIGRATION

A pathline analysis was performed to assess the effect of the Columbia River stage on the transport of nonattenuated contaminants in the ground water. The analysis assumed that the pathlines originated in the unconfined aquifer directly beneath the 183-H basins. The CFEST computer code (Gupta 1982) was used to estimate flow paths and velocities for nonattenuated contaminants (e.g., chromium, nitrate), using water-level data and estimated hydrologic properties of the aquifer.

The transient flow simulation used for the pathline analysis required a 6-year simulated period to allow all of the contaminant particles to reach the river. The river fluctuations were simulated using weekly weighted

9 2 1 2 6 4 1 0 7 0 5

TABLE 4. Contaminants Reported Above the Drinking Water Standard in the 100-H Area Wells During 1987

| Well Number | Gross Alpha | Gross Beta | Filtered Chromium | Nonfiltered Chromium | Coliform Bacteria | Nitrate |
|---|---|---|---|---|---|---|
| 199-H3-1 | | | X | X | | X |
| 199-H3-2A | | | X | X | | |
| 199-H3-2B | | | X | | | |
| 199-H3-2C | | | | | X | |
| 199-H4-3 | X | X | X | X | X | X |
| 199-H4-4 | X | X | X | X | X | X |
| 199-H4-5 | | | X | X | | |
| 199-H4-6 | | | X | X | | |
| 199-H4-7 | | | X | X | X | |
| 199-H4-8 | | | X | X | X | |
| 199-H4-9 | | X | X | X | | X |
| 199-H4-10 | | | X | X | | |
| 199-H4-11 | | X | X | X | X | |
| 199-H4-12A | X | X | X | X | X | X |
| 199-H4-12B | X | X | X | X | | X |
| 199-H4-12C | | | X | X | X | |
| 199-H4-13 | | X | | | X | |
| 199-H4-14 | | | X | X | | |
| 199-H4-15A | | | X | X | | X |
| 199-H4-15B | | | X | X | | |
| 199-H4-16 | | | | | | |
| 199-H4-17 | | | X | X | X | X |
| 199-H4-18 | | X | X | X | | X |
| Range | 15.5 to 269.0 pCi/L | 54.6 to 908 pCi/L | 50 to 428 ppb | 52 to 437 ppb | 2.2 to 16.0 MPN[(a)] | 45,000 to 1,020,000 ppb |
| Total Number of Wells | 4 | 8 | 20 | 19 | 10 | 9 |
| Drinking Water Standard | 15 pCi/L | 50 pCi/L | 50 ppb | 50 ppb | 1 MPN | 45,000 ppb |

(a) MPN = most probable number.

9 2 1 2 6 4 1 0 7 0 6

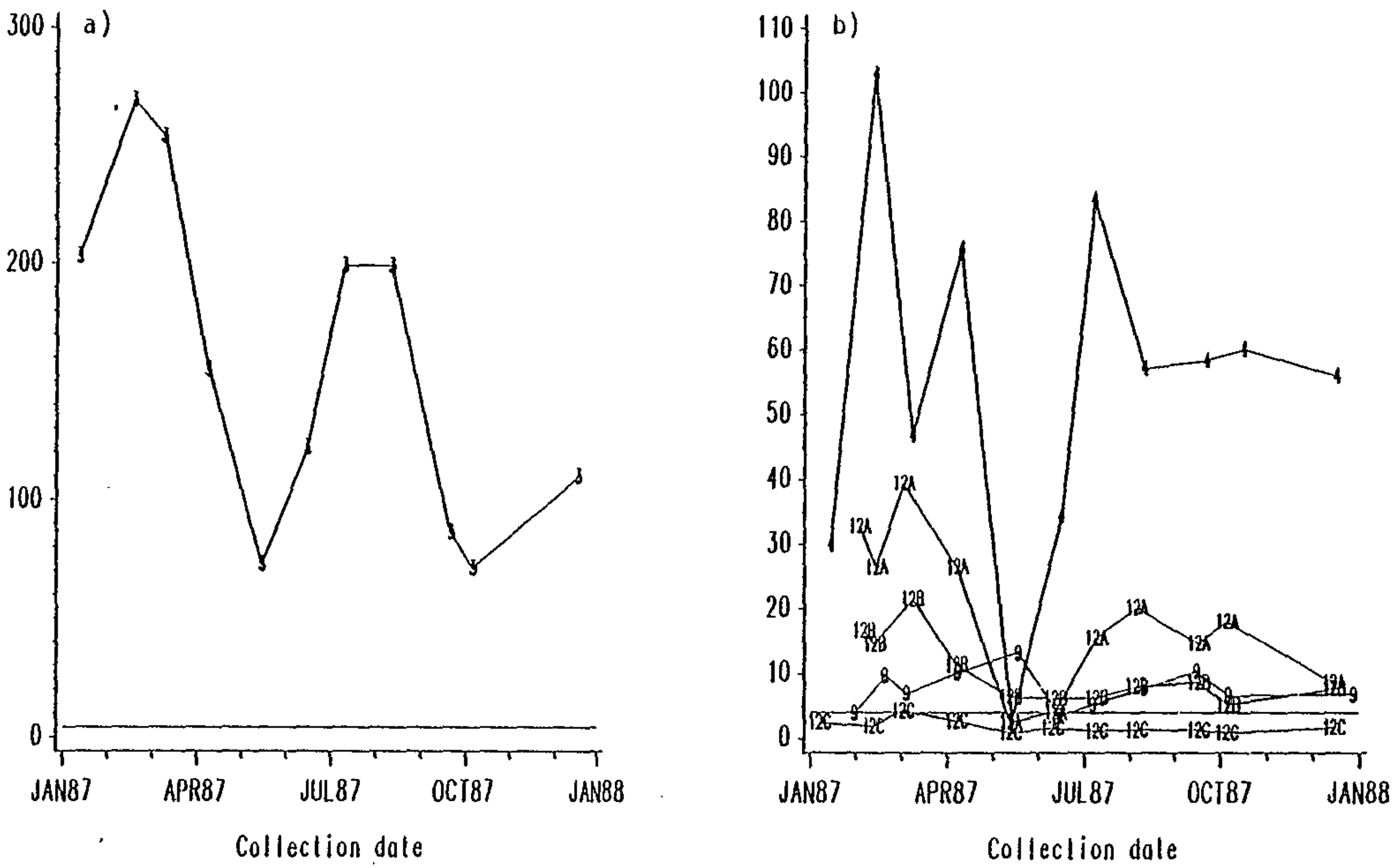


FIGURE 17. Gross Alpha Concentrations (pCi/L) in 100-H Area Wells. a) Well 199-H4-3; b) Other Wells Most Affected by the 183-H Solar Evaporation Basins.

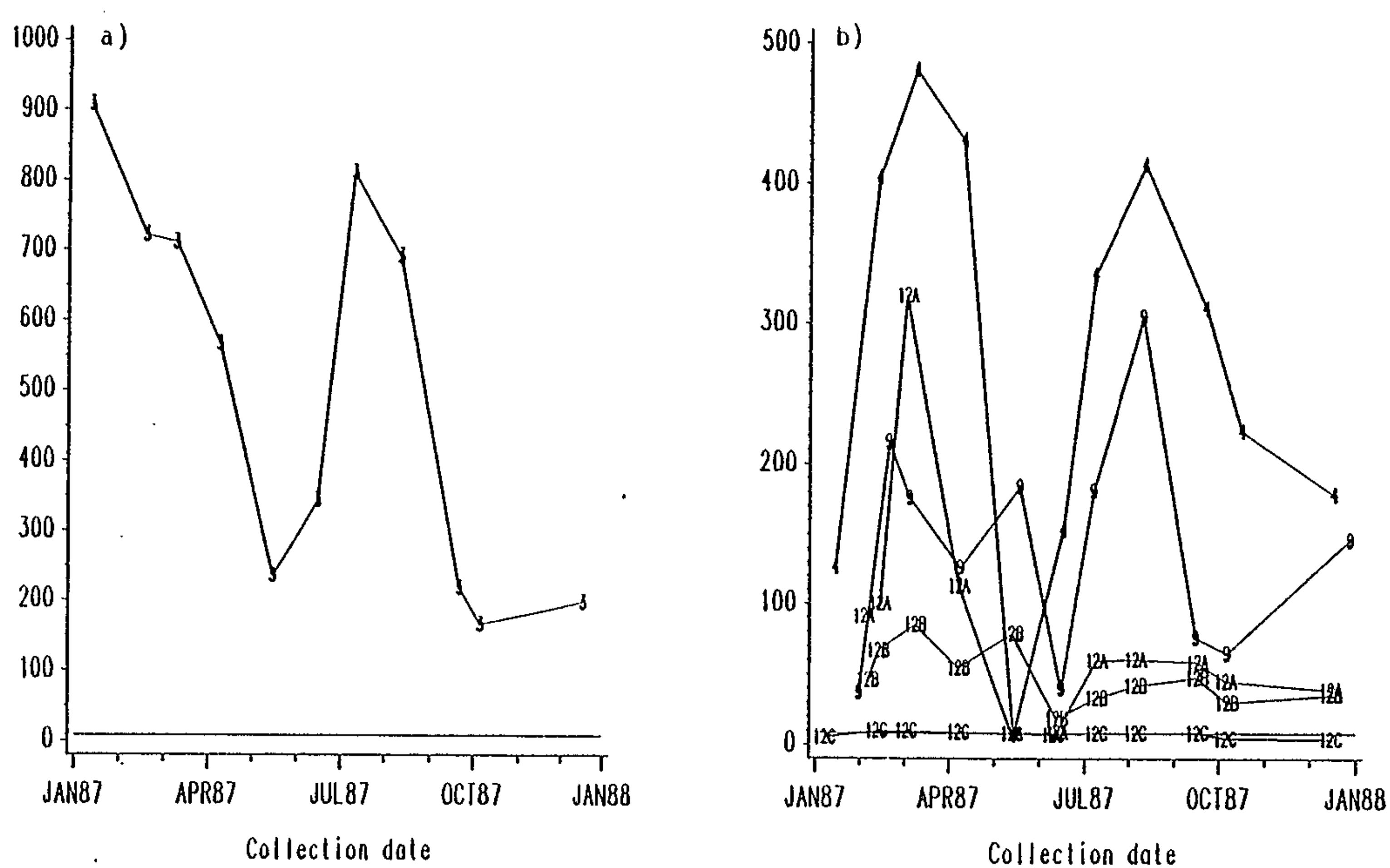


FIGURE 18. Gross Beta Concentrations (pCi/L) in 100-H Area Wells. a) Well 199-H4-3; b) Other Wells Most Affected by the 183-H Solar Evaporation Basins.

9 2 1 2 6 4 1 0 7 0 8

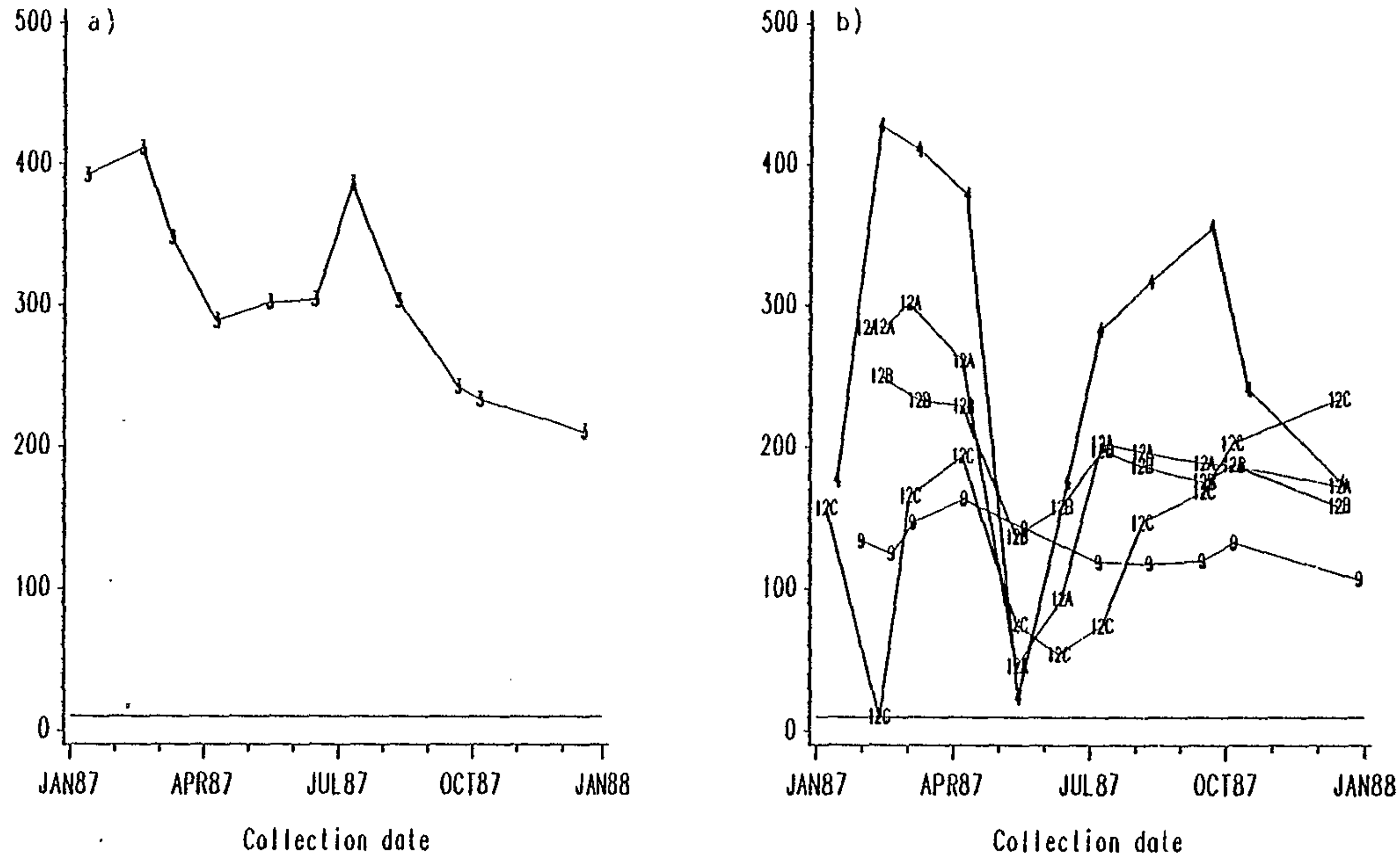


FIGURE 19. Filtered Chromium Concentrations (ppb) in 100-H Area Wells. a) Well 199-H4-3; b) Other Wells Most Affected by the 183-H Solar Evaporation Basins.

9 2 1 2 5 4 1 0 7 0 9

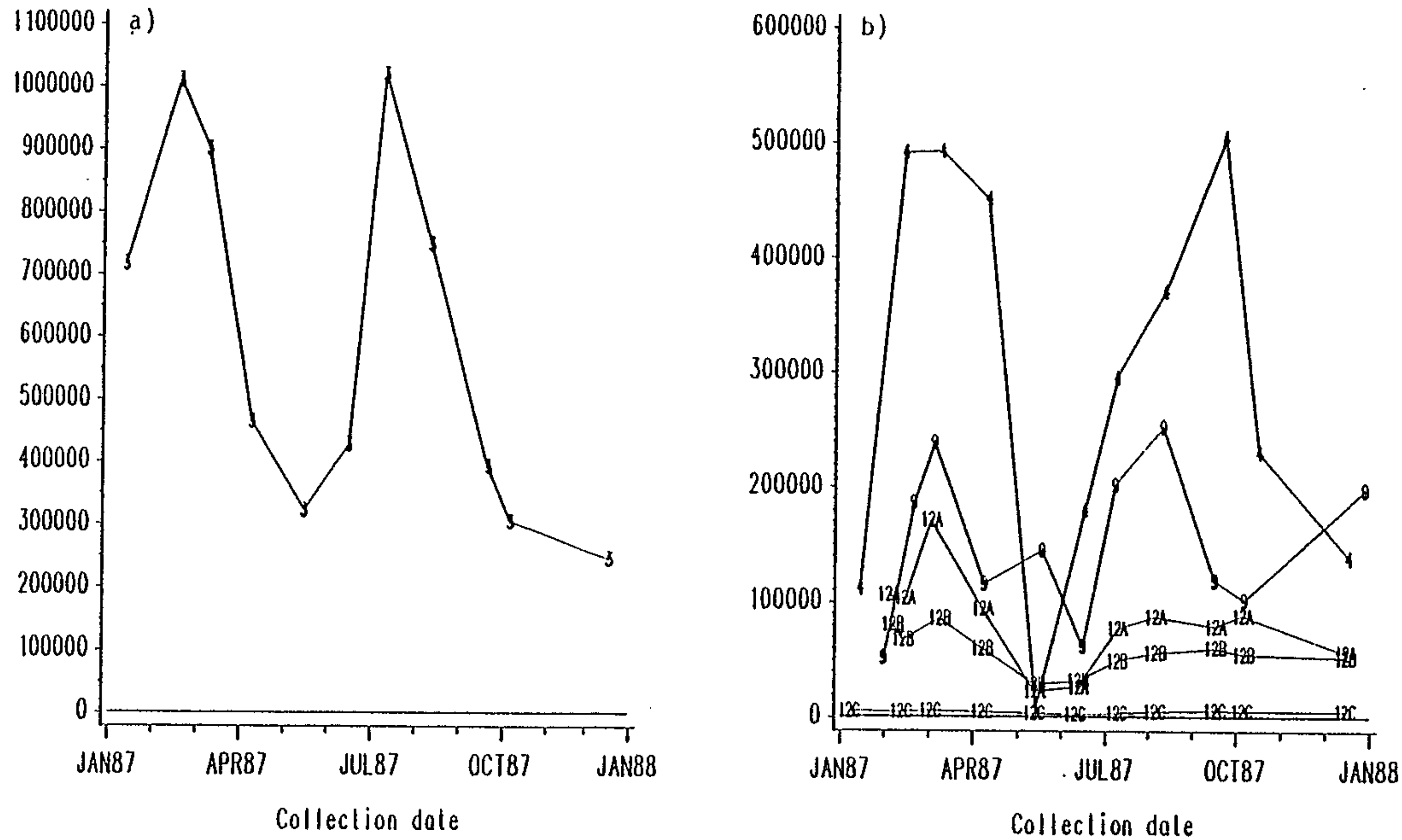


FIGURE 20. Nitrate Concentrations (ppb) in 100 Area Wells. a) Well 199-H4-3; b) Other Wells Most Affected by the 183-H Solar Evaporation Basins.

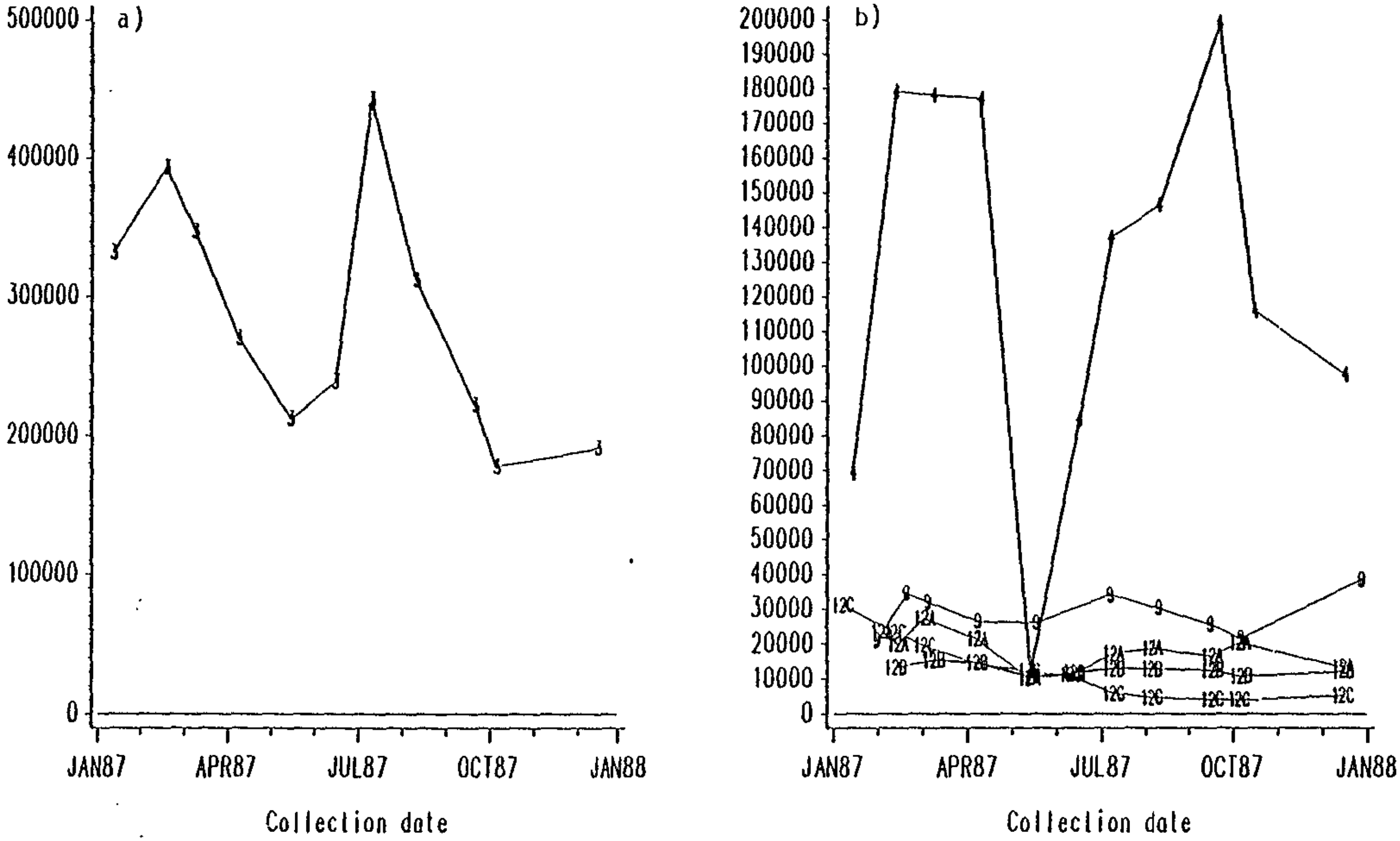


FIGURE 21. Filtered Sodium Concentrations (ppb) in 100 Area Wells. a) Well 199-H4-3; b) Other Wells Most Affected by the 183-H Solar Evaporation Basins.

averages for the river level. The river-level data from September 1986 to September 1987 were considered to be representative of a yearly cycle in river stage and were repeated for six 1-year cycles.

Eight contaminant pathlines were simulated. The travel times and distances for these pathlines are shown in Table 5. The travel times range from 1 to 4 years, while the distances traveled range from 600 to 1400 ft. The spread in times and distances traveled reflect the variable flow paths resulting from changes in the water table that, in turn, are caused by the fluctuating river stage. The average travel time is 3 years, and the average distance traveled is 1000 ft. The average seepage velocity based on the travel times and total distances is 1 ft/d. The actual flow velocities vary considerably, especially near the river as a result of the steeper hydraulic gradients. A lateral spread of 170 ft was observed for the locations where the flow paths entered the Columbia River. Observed distribution of contaminants in the plume attributable to the 183-H basins is consistent with the plume envelope (Figure 22) that bounds the eight simulated flow paths.



TABLE 5. Travel Times and Distances

| | Travel Time, yr | Travel time, d | Distance, ft | Average Velocity, ft/d |
|---|---|---|---|---|
| Path 1 | 4.1 | 1490 | 1290 | 0.86 |
| Path 2 | 3.0 | 1100 | 970 | 0.88 |
| Path 3 | 1.2 | 450 | 610 | 1.34 |
| Path 4 | 3.5 | 1200 | 1130 | 0.88 |
| Path 5 | 2.1 | 770 | 830 | 1.07 |
| Path 6 | 2.1 | 750 | 1000 | 1.33 |
| Path 7 | 4.0 | 1460 | 1360 | 0.93 |
| Path 8 | 2.4 | 880 | 840 | 0.96 |
| Average | 2.8 | 1030 | 1000 | 1.03 |

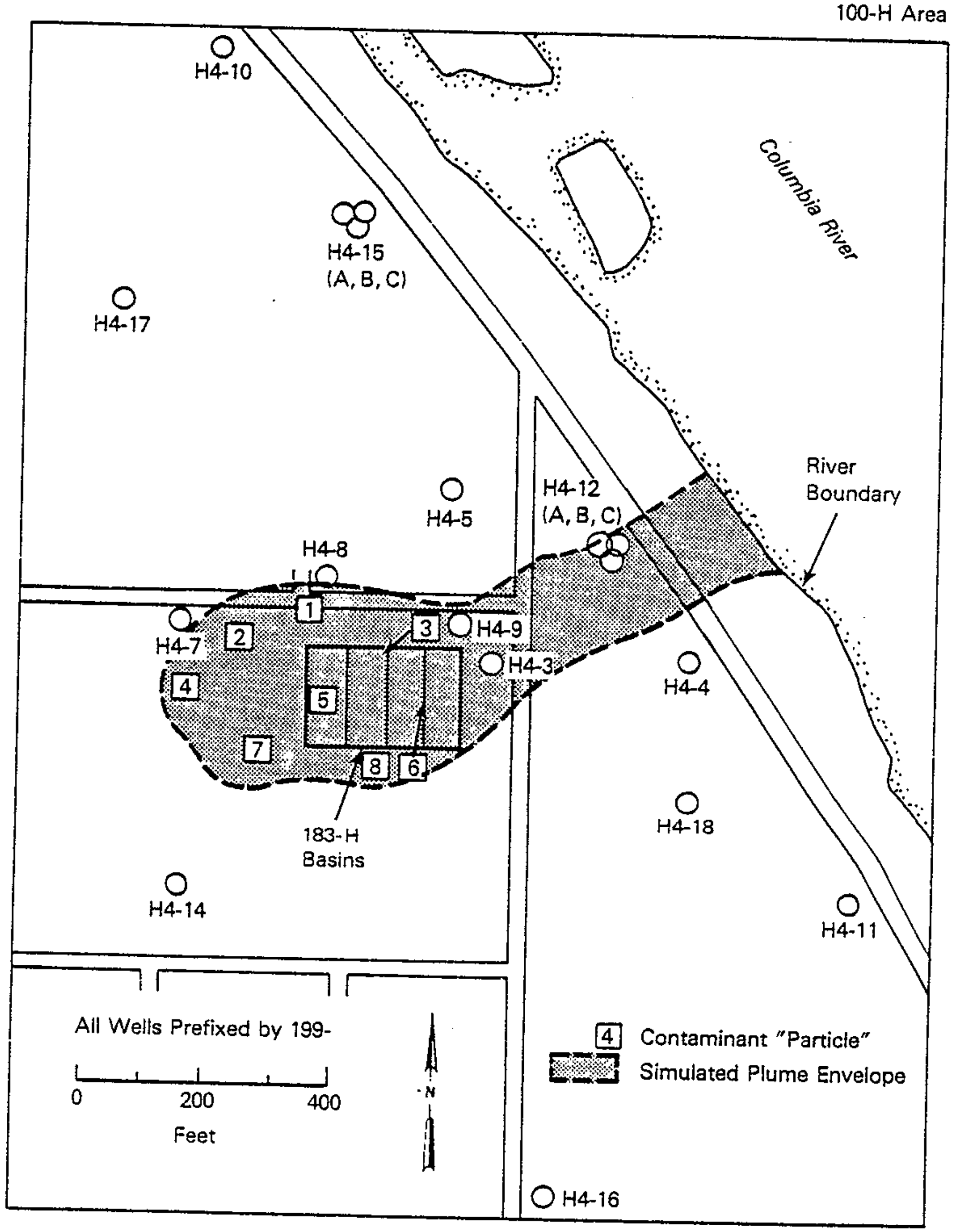


FIGURE 22. Simulated Contaminant Pathlines. Combined flow paths toward a river, simulated for eight contaminant particles, are contained within the shaded plume.

# 200 AREAS LOW-LEVEL BURIAL GROUNDS

G. V. Last

The major activity of the interim-status RCRA detection-level ground-water monitoring project for the 200 Areas Low-Level Burial Grounds in 1987 consisted of completion of the 35 monitoring wells between June and November.

The 200 Areas Low-Level Burial Grounds have been grouped into four waste management areas (WMAs) for detection monitoring. Two of the WMAs are located in the 200-East Area and two in the 200-West Area (Figures 23 and 24). Separate ground-water monitoring systems were installed around each WMA.

## WATER-LEVEL MEASUREMENTS

The potentiometric surface of the uppermost aquifer is defined by measuring the depth to water in each of the newly installed monitoring wells. This measurement is then subtracted from the surveyed elevation of the well head to yield the elevation of the water table. Ground-water flow directions beneath WMA 1 and WMA 2 in the 200-East Area are generally from east to west, while those beneath WMA 3 and WMA 4 in the 200-West Area are generally from south to north (Figures 25 and 26) and controlled by the U Pond ground-water mound. Contours shown in the figures represent most recent (February 1988) data, principally from the 35 monitoring wells, and are useful in distinguishing upgradient and downgradient monitoring points for each WMA.



## WATER QUALITY

Routine ground-water sampling has not yet been initiated because pumps were not received and installed during the quarter. Therefore, the water quality has not been established.

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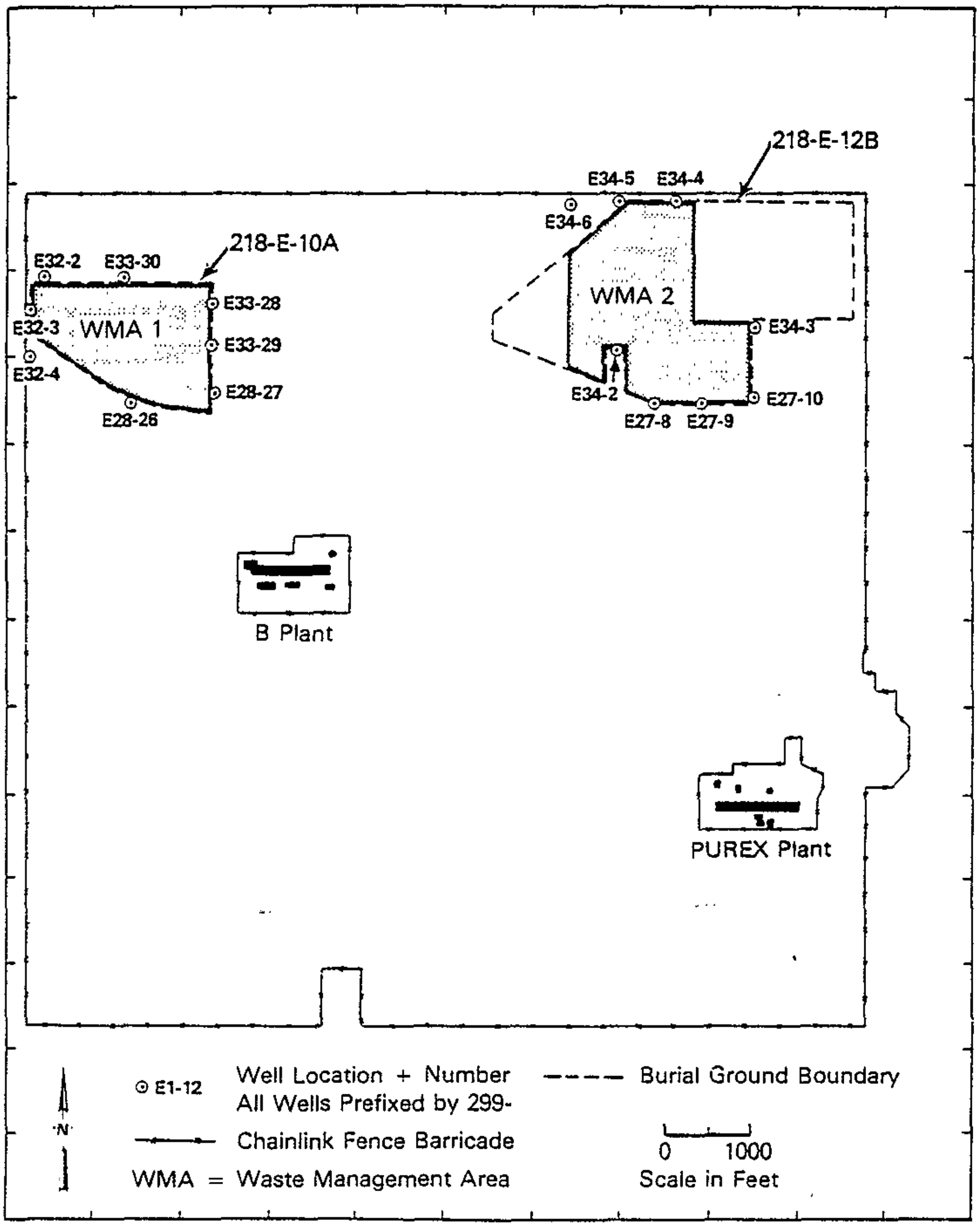


FIGURE 23. Detection-Level Monitoring Wells in the 200-East Area

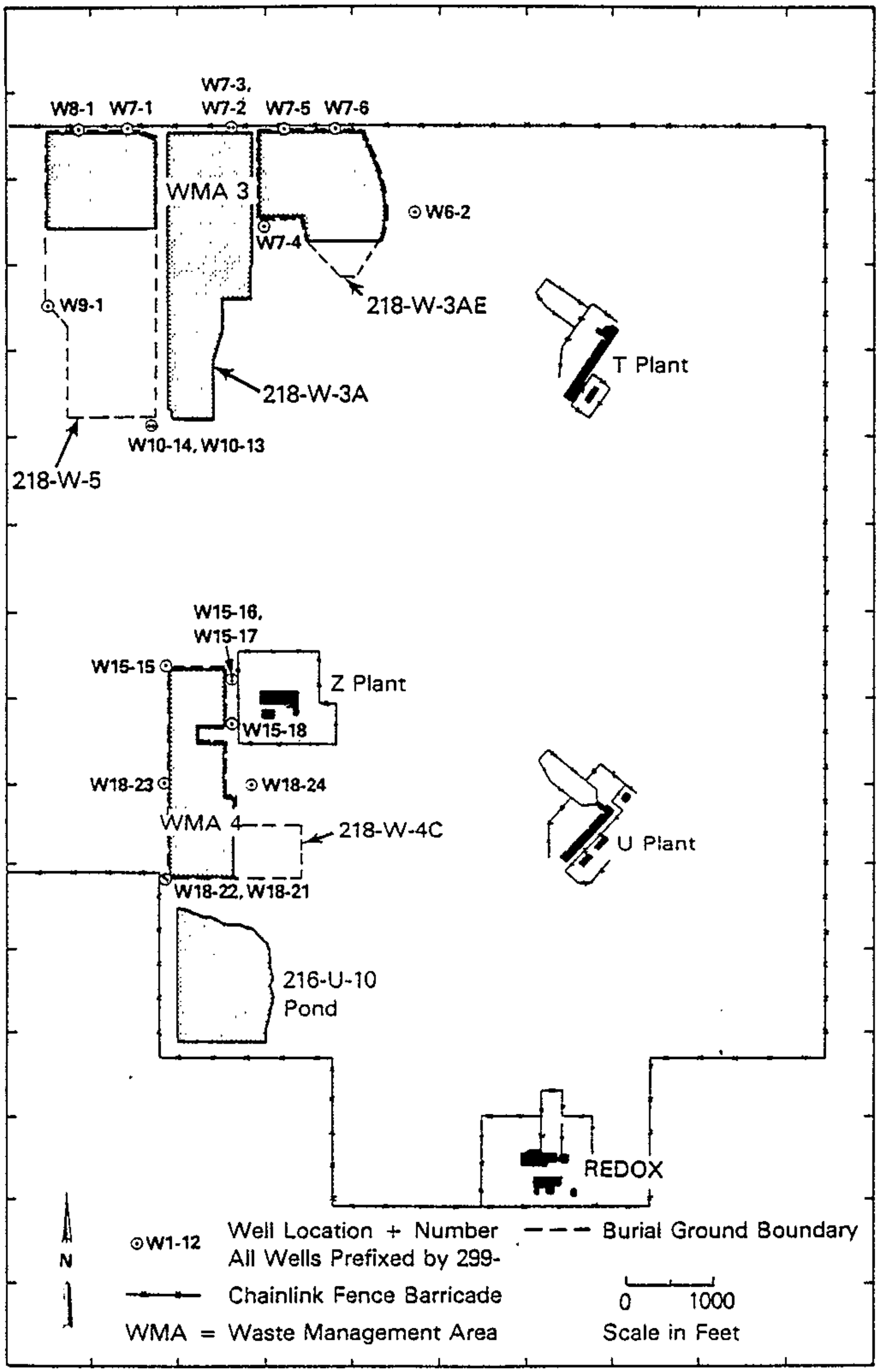


FIGURE 24. Detection-Level Monitoring Wells in the 200-West Area

9212641071 5

92126410716

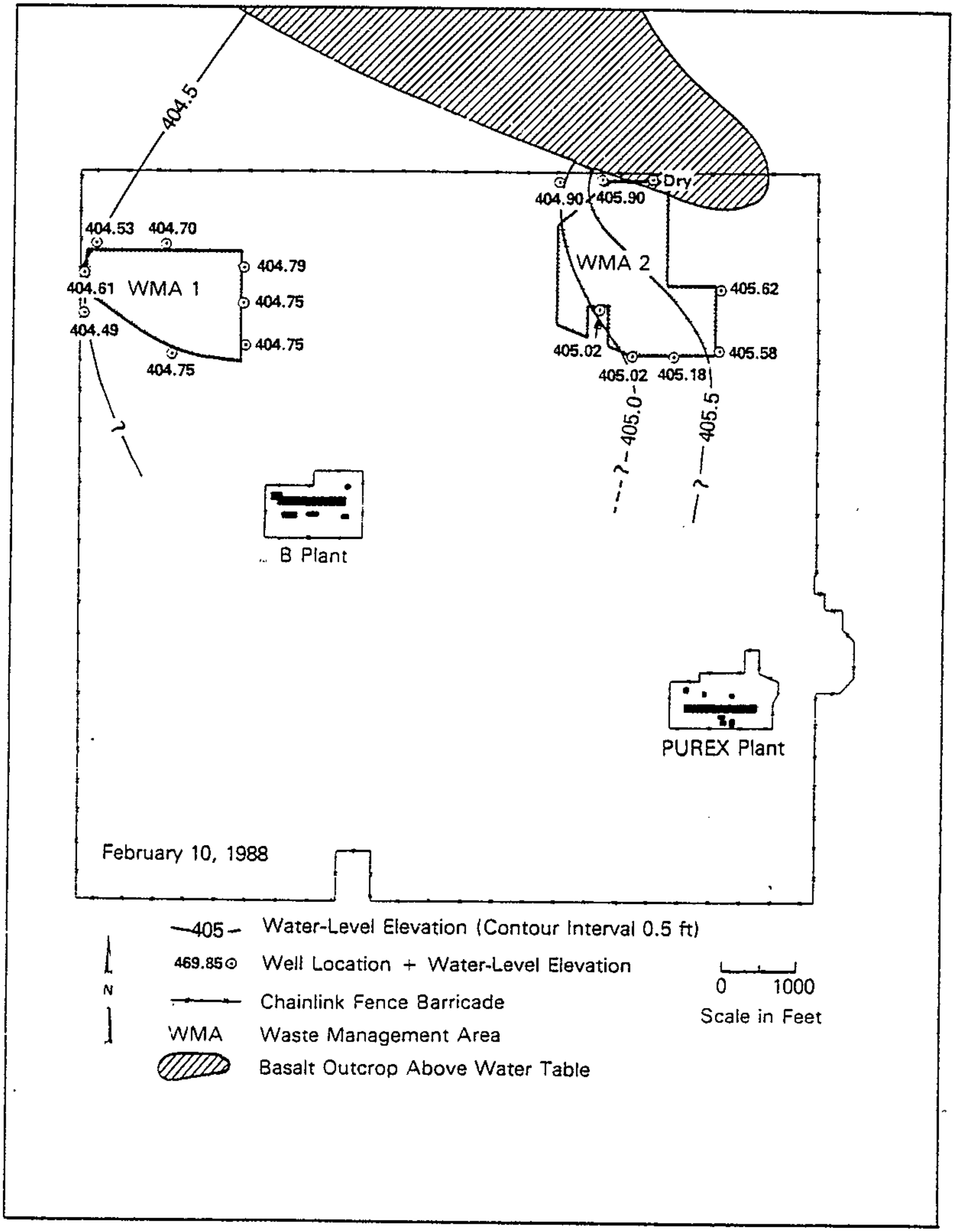


FIGURE 25. Water-Table Elevations in the 200-East Area

9212641071 7

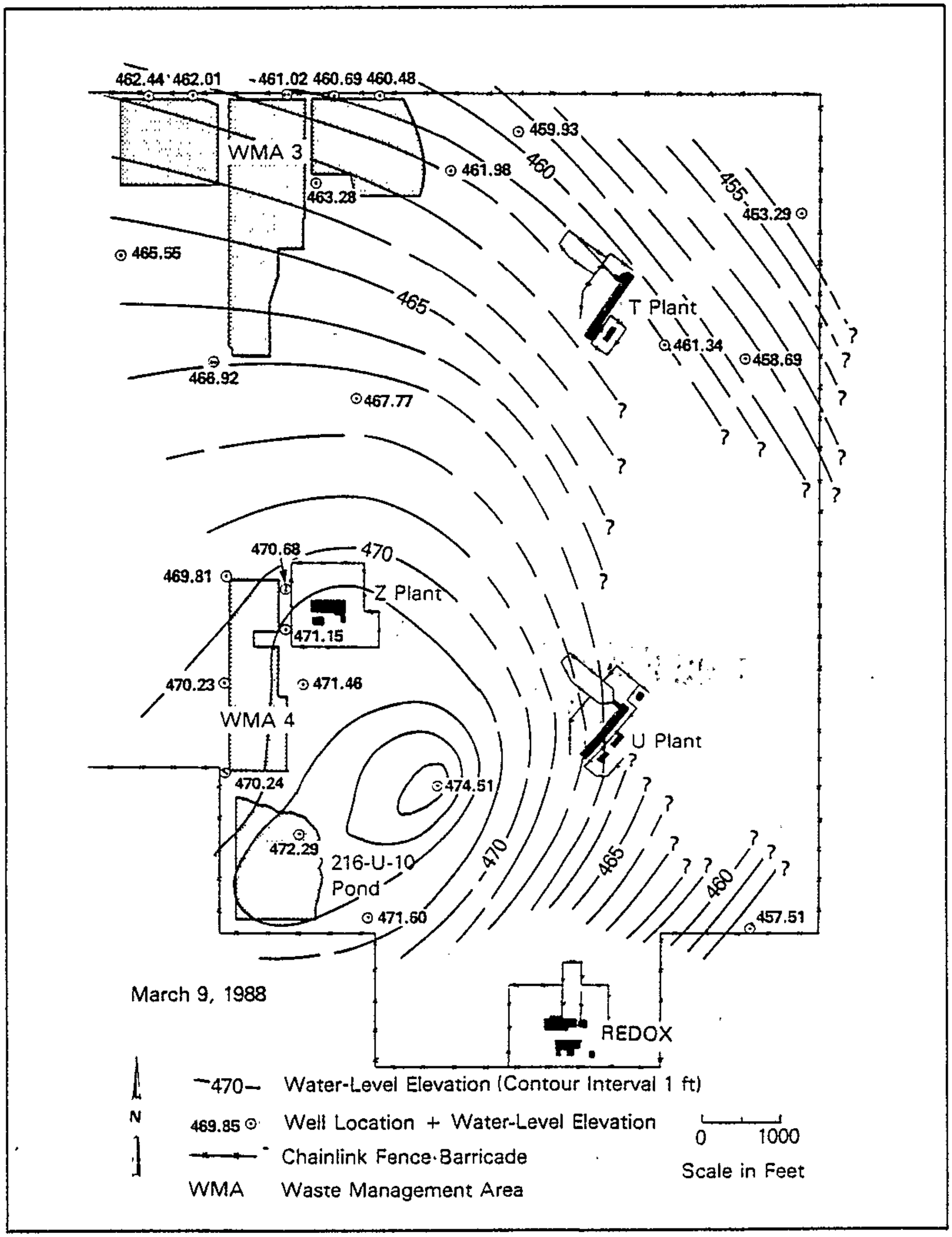


FIGURE 26. Water-Table Elevations in the 200-West Area

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# NONRADIOACTIVE DANGEROUS WASTE LANDFILL

R. M. Fruland

Major activities of the RCRA detection-level ground-water monitoring project for the Nonradioactive Dangerous Waste Landfill (NRDW) completed during 1987 include the following:

- completion of the two deep monitoring wells (for a total of seven)
- preparation of the NRDW site interim characterization report (Weekes, Luttrell, and Fuchs 1987)
- four rounds of sampling and analysis.

Three upgradient wells and four downgradient wells are included in this project. One of the upgradient and one of the downgradient wells were completed in the bottom of the uppermost aquifer to determine the vertical extent of contamination. Figure 27 shows the locations of the ground-water monitoring wells at the NRDW.

## WATER-LEVEL MEASUREMENTS

Figures 27, 28, and 29 show the general water-table and ground-water flow information in the vicinity of the NRDW based on same-day water-table elevation measurements of Hanford Site wells (Weekes, Luttrell, and Fuchs 1987). In 1987, water levels were measured in the NRDW wells as part of the interim site characterization effort. The difference in ground-water flow direction (between Figures 28 and 29) reflects the inability to determine small water-level differences accurately in an area of extremely low ground-water gradient, which is on the order of 0.0001 beneath the Central Landfill (CLF).

## WATER QUALITY

The ground-water quality is evaluated by 1) characterizing the first year of background data for the four contamination indicator parameters as

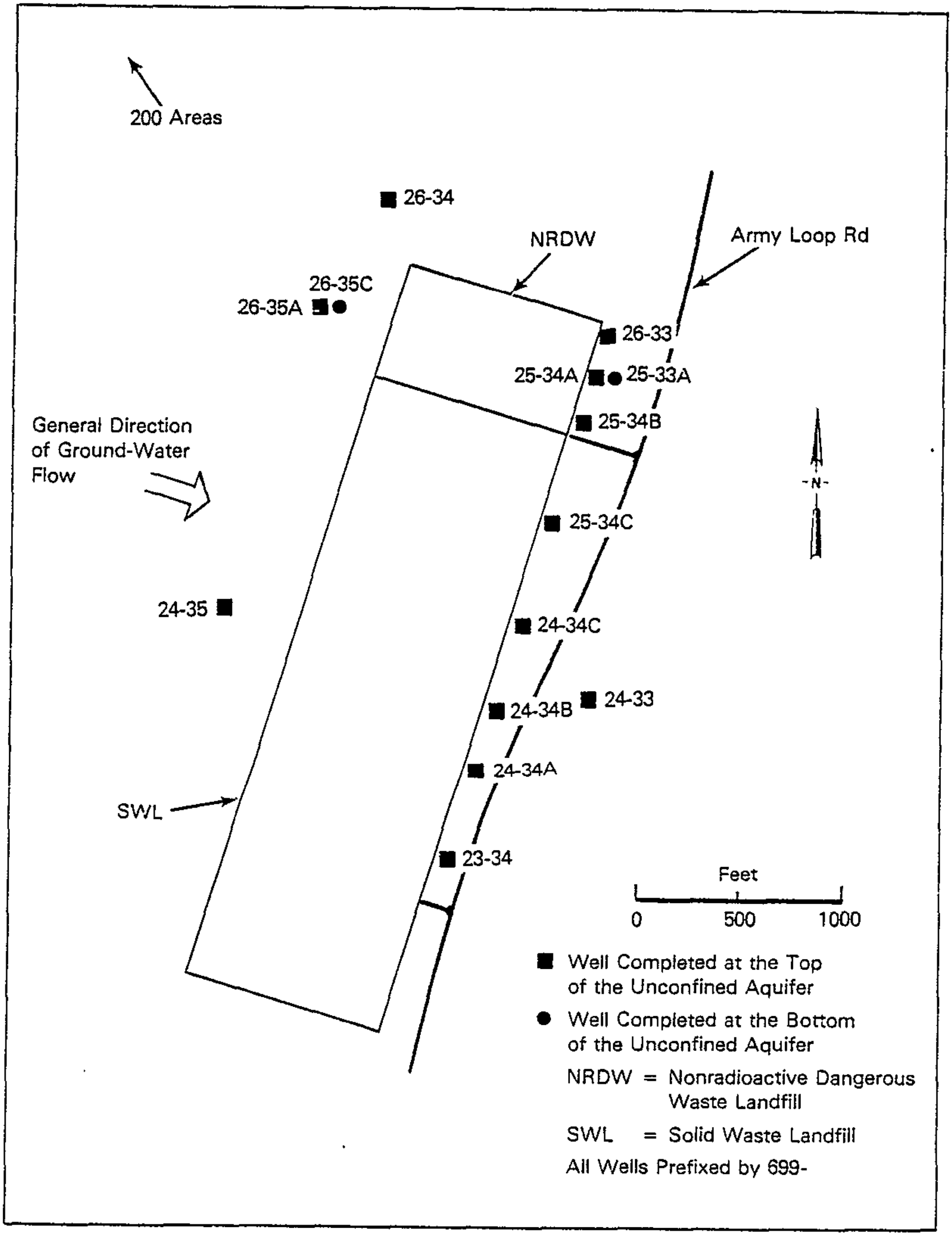


FIGURE 27. Ground-Water Monitoring Well Locations at the Central Landfill that Includes the Solid Waste Landfill and the Nonradioactive Dangerous Waste Landfill

9 2 1 2 5 4 1 0 7 1 9

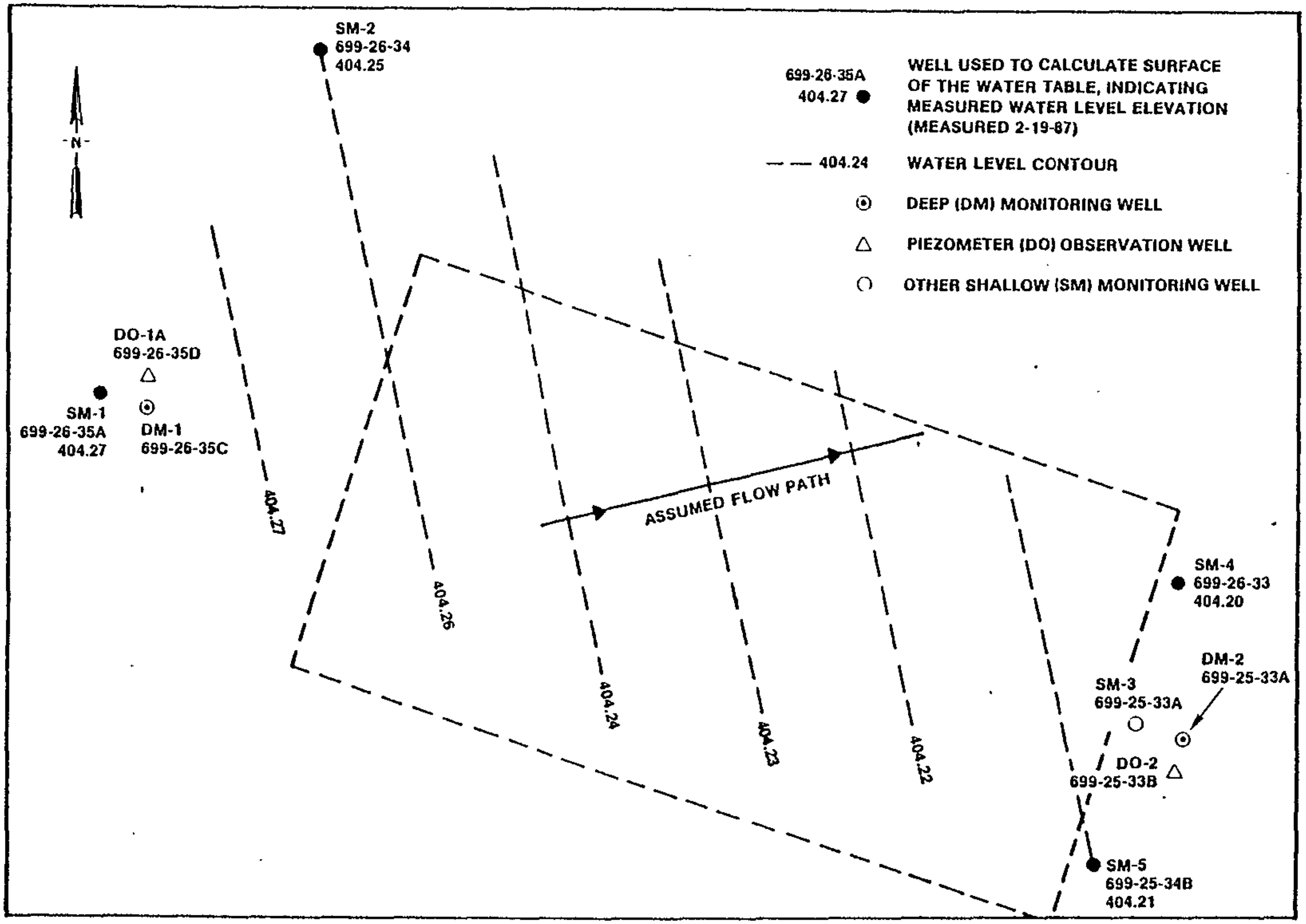


FIGURE 28. Water-Table and Ground-Water Flow Directions Beneath the Nonradioactive Dangerous Waste Landfill Incorporating Same-Day Water-Level Measurements in Regional and Nonradioactive Dangerous Waste Landfill Wells (from Weekes, Luttrell, and Fuchs 1987)

9 2 1 2 6 4 1 0 7 2 1

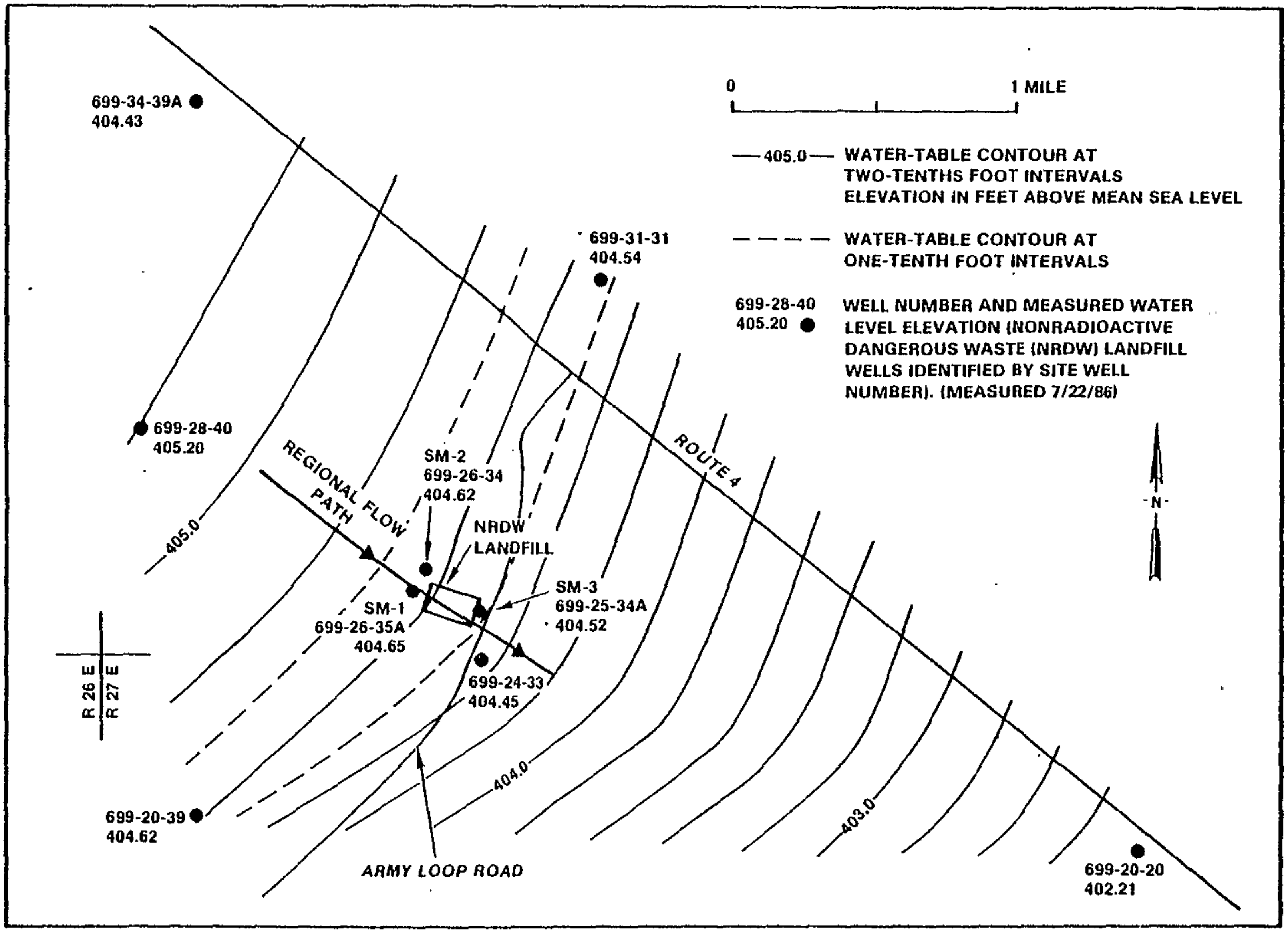


FIGURE 29. Water-Table and Ground-Water Flow Directions Beneath the Nonradioactive Dangerous Waste Landfill Based on 7-Day Mean Water-Level Measurements in the Nonradioactive Dangerous Waste Landfill and Regional Well Data (after Weekes, Luttrell, and Fuchs 1987)

specified in 40 CFR 265.92(c) (EPA 1987), and 2) statistically testing the first set of detection data for indications of ground-water contamination as specified in 40 CFR 265.93(b) (EPA 1987).

<u>Water Quality</u>

Raw data available for the indicator parameters [specific conductance, pH, total organic halogens (TOX) and total organic carbons (TOC)] are presented in Table 6. Statistical summaries of the data are presented in Table 7. The pH data have also been expressed as hydrogen ion ($H_3O^+$) concentrations in moles/liter as well as in standard pH units, as suggested in the RCRA <u>Technical Enforcement Guidance Document</u> (TEGD) (EPA 1986). In general, the field measurements exhibit very good replication, with coefficients of variation typically less than 4%. However, the laboratory-analyzed TOX and TOC indicator parameters exhibit a high degree of variability (10 to 100%), which may represent analytical variability near detection limits.



Background data for the first year were statistically evaluated using several techniques applied to the averaged replicate data collected quarterly in the upgradient wells. The general methodology is given in Appendix B of the RCRA TEGD (EPA 1986). Actual TOX and TOC results are usually reported by the analytical laboratory even though they may be below the contractual detection limit. The data were used as reported with the following exceptions. The TOX data for January 1987 were not included in establishing background water quality because for that month, the data were reported by the laboratory as less than the contractual detection limit of 100 ppb rather than as an actual analytical result. This value is inconsistent with other values measured at the NRDW, especially when a similar analysis for TOX with a contractual detection limit of 20 ppb did not indicate any TOX values greater than 20 ppb. The TOX data were analyzed with and without data from well 699-26-35C (measured on July 30, 1987), which appear quite different from the rest of the background data. Average replicate summary statistics are presented in Table 8 and Figure 30.

The statistical comparison procedure recommended in the TEGD is an averaged replicate student's t-test with the critical points selected at the $\alpha$=0.01 significance level using the Bonferroni inequality to account for the

TABLE 6. Nonradioactive Dangerous Waste (NRDW) Landfill Detection Level Program Contamination Indicator Parameters Raw Data

| Well Number | Sample Date | Rep. Number | CONDFLD | CONDLAB | PHFIELD | PH LAB | TOC | TOX | TOXLDL |
|---|---|---|---|---|---|---|---|---|---|
| | | | Upgradient Wells | | | | | | |
| 699-26-35A | 10/1/86 | | 411 | | 7.0 | | #32 | #13.7 | |
| | | 1 | 411 | | 7.0 | | | | |
| | | 2 | 410 | | 7.0 | | | | |
| | | 3 | 410 | | 7.1 | | | | |
| | 1/20/87 | | 355 | | 6.9 | | #368 | <100 | <20.0 |
| | | 1 | 361 | | 6.9 | | #293 | <100 | |
| | | 2 | 362 | | 6.9 | | #278 | <100 | |
| | | 3 | 365 | | 6.9 | | #345 | <100 | |
| | 5/27/87 | | 371 | | 7.5 | | #531 | #12.3 | |
| | | 1 | 363 | | 7.5 | | #328 | #4.1 | |
| | | 2 | 358 | | 7.5 | | #515 | #0.6 | |
| | | 3 | 356 | | 7.5 | | #598 | #14.2 | |
| | 7/30/87 | | 342 | | 7.4 | | #495 | #6.5 | |
| | | 1 | 341 | | 7.5 | | #395 | #6.2 | |
| | | 2 | 340 | | 7.5 | | #378 | #1.3 | |
| | | 3 | 340 | | 7.5 | | #352 | #2.8 | |
| | 11/15/87 | | 372 | 333 | 6.9 | 7.97 | #464 | #4.8 | |
| | | 1 | 371 | | 6.8 | | 3730 | #4.2 | |
| | | 2 | 370 | | 6.8 | | #544 | #8.4 | |
| | | 3 | 369 | | 6.8 | | #320 | #6.6 | |
| 699-26-34 | 10/1/86 | | 397 | | 7.0 | | #117 | #7.0 | |
| | | 1 | 397 | | 7.1 | | | | |
| | | 2 | 396 | | 7.2 | | | | |
| | | 3 | 397 | | 7.2 | | | | |
| | 1/21/87 | | 344 | | 6.8 | | #397 | <100 | <20.0 |
| | | 1 | 354 | | 7.0 | | #326 | <100 | |
| | | 2 | 365 | | 7.0 | | #343 | <100 | |
| | | 3 | 367 | | 7.1 | | #279 | <100 | |
| | 5/26/87 | | 352 | | 7.5 | | #302 | #9.6 | |
| | | 1 | 352 | | 7.5 | | #452 | #3.1 | |
| | | 2 | 367 | | 7.6 | | #369 | #25.3 | |
| | | 3 | 358 | | 7.6 | | #379 | #2.4 | |
| | 7/30/87 | | 288 | | 6.9 | | #441 | #3.9 | |
| | | 1 | 279 | | 7.0 | | #396 | #7.8 | |
| | | 2 | 279 | | 7.0 | | #440 | #3.4 | |
| | | 3 | 280 | | 7.0 | | #500 | #7.4 | |
| | 11/15/87 | | 361 | 333 | 6.7 | 8.04 | #362 | #12.3 | |
| | | 1 | 359 | | 6.7 | | #706 | #4.4 | |
| | | 2 | 358 | | 6.6 | | #426 | #4.3 | |
| | | 3 | 358 | | 6.5 | | #346 | #11.6 | |
| 699-26-35C (deep) | 1/21/87 | | 339 | | 7.6 | | #225 | <100 | <20.0 |
| | | 1 | 340 | | 7.6 | | #234 | <100 | |
| | | 2 | 369 | | 7.3 | | #214 | <100 | |
| | | 3 | 388 | | 7.2 | | #239 | <100 | |

# TABLE 6. (contd)

| Well Number | Sample Date | Rep. Number | CONDFLD | CONDLAB | PHFIELD | PH LAB | TOC | TOX | TOXLDL |
|---|---|---|---|---|---|---|---|---|---|
| | 5/27/87 | | 370 | | 7.6 | | #292 | #3.4 | |
| | | 1 | 370 | | 7.5 | | #315 | #0.0 | |
| | | 2 | 370 | | 7.6 | | #297 | #0.0 | |
| | | 3 | 378 | | 7.6 | | #412 | #0.0 | |
| | 7/30/87 | | 359 | | 7.0 | | #344 | 203 | |
| | | 1 | 357 | | 7.0 | | #377 | 230 | |
| | | 2 | 356 | | 7.1 | | #510 | 230 | |
| | | 3 | 357 | | 7.1 | | #296 | 229 | |
| | 11/15/87 | | 424 | 375 | 4.8 | 8.06 | B | #5.4 | |
| | | 1 | 424 | | 4.6 | | #407 | #4.1 | |
| | | 2 | 424 | | 4.5 | | #191 | #4.3 | |
| | | 3 | 423 | | 4.4 | | #293 | #6.7 | |
| Downgradient Wells | | | | | | | | | |
| 699-26-33 | 10/1/86 | | 397 | | 7.0 | | #563 | #6.5 | |
| | 1/20/87 | | 380 | | 7.1 | | #284 | <100 | <20.0 |
| | 5/26/87 | | 369 | | 7.6 | | 1470 | #24.9 | |
| | 7/29/87 | | 330 | | 7.5 | | #375 | #31.1 | |
| | 10/29/87 | | 379 | 370 | 7.1 | 7.96 | 1290 | #19.0 | |
| 699-25-34B | 10/1/86 | | 406 | | 6.8 | | #202 | #18.4 | |
| | 1/21/87 | | 380 | | 7.0 | | #433 | <100 | <20.0 |
| | 5/26/87 | | 381 | | 7.4 | | #331 | 270 | |
| | 7/29/87 | | 357 | | 7.4 | | #335 | #11.7 | |
| | 10/29/87 | | 437 | 495 | 8.1 | 7.82 | #589 | #2.6 | |
| 699-25-34A | 10/1/86 | | 394 | | 7.1 | | #140 | #11.4 | |
| | 1/20/87 | | 380 | | 7.1 | | #483 | <100 | <20.0 |
| | 5/26/87 | | 387 | | 7.5 | | #285 | #0.8 | |
| | 7/29/87 | | 347 | | 7.4 | | #354 | #5.6 | |
| | 10/29/87 | | 471 | 417 | 6.8 | 7.72 | #643 | #14.7 | |
| 699-25-33A | 1/21/87 | | 328 | | 7.4 | | #218 | <100 | <20.0 |
| (deep) | 5/27/87 | | 316 | | 8.3 | | #409 | #5.0 | |
| | 7/29/87 | | 371 | | 7.8 | | #378 | #5.1 | |
| | 11/15/87 | | 413 | 365 | 6.0 | 8.26 | 1320 | #10.2 | |

CONDFLD = Specific conductance (μmho) measured in the field.
CONDLAB = Specific conductance (μmho measured in the laboratory.
PHFIELD = pH measured in the field.
PH-LAB = pH measured in the laboratory.
TOC = Total organic carbon (ppb) contractual detection limit of 1000 ppb
TOX = Total organic halogens (ppb) contractual detection limit of 100 ppb
TOXLDL = Total organic halogens (ppb) contractual detection limit of 20 ppb

B = broken sample container.
< = Value was reported as contractual detection limit.
# = Reported value is below contractual detection limit.

TABLE 7. Statistical Summaries of Replicate Measurements for the Nonradioactive Dangerous Waste Landfill

Constituent Code[a], Name, Analysis Units = 191 CONDFLD (umho)

| Well Number | Sample Date | Replicates | Mean | Variance | Standard Deviation | Coefficient of Variation |
|---|---|---|---|---|---|---|
| 699-2699-35A | 10/1/86 | 4 | 410.5 | 0.33 | 0.58 | 0.1 |
| | 1/20/87 | 4 | 360.8 | 17.58 | 4.19 | 1.2 |
| | 5/27/87 | 4 | 362.0 | 44.67 | 6.68 | 1.8 |
| | 7/30/87 | 4 | 340.8 | 0.92 | 0.96 | 0.3 |
| | 11/15/87 | 4 | 370.5 | 1.67 | 1.29 | 0.3 |
| 699-26-34 | 10/1/86 | 4 | 396.8 | 0.25 | 0.50 | 0.1 |
| | 1/21/87 | 4 | 357.5 | 113.67 | 10.66 | 3.0 |
| | 5/26/87 | 4 | 357.3 | 50.25 | 7.09 | 2.0 |
| | 7/30/87 | 4 | 281.5 | 19.00 | 4.36 | 1.5 |
| | 11/15/87 | 4 | 359.0 | 2.00 | 1.41 | 0.4 |
| 699-26-35C (deep) | 1/21/87 | 4 | 359.0 | 567.33 | 23.82 | 6.6 |
| | 5/27/87 | 4 | 372.01 | 6.00 | 4.00 | 1.1 |
| | 7/30/87 | 4 | 357.3 | 1.58 | 1.26 | 0.4 |
| | 11/15/87 | 4 | 423.8 | 0.25 | 0.50 | 0.1 |

Constituent Code[a], Name, Analysis Units = 199 PHFIELD

| Well Number | Sample Date | Replicates | Mean | Variance | Standard Deviation | Coefficient of Variation |
|---|---|---|---|---|---|---|
| 699-26-35A | 10/1/86 | 4 | 7.03 | 0.0025 | 0.050 | 0.7 |
| | 1/20/87 | 4 | 6.90 | 0.0000 | 0.000 | 0.0 |
| | 5/27/87 | 4 | 7.50 | 0.0000 | 0.000 | 0.0 |
| | 7/30/87 | 4 | 7.48 | 0.0025 | 0.050 | 0.7 |
| | 11/15/87 | 4 | 6.83 | 0.0025 | 0.050 | 0.7 |
| 699-26-34 | 10/1/86 | 4 | 7.13 | 0.0092 | 0.096 | 1.3 |
| | 1/21/87 | 4 | 6.98 | 0.0158 | 0.126 | 1.8 |
| | 5/26/87 | 4 | 7.55 | 0.0033 | 0.058 | 0.8 |
| | 7/30/87 | 4 | 6.98 | 0.0025 | 0.050 | 0.7 |
| | 11/15/87 | 4 | 6.63 | 0.0092 | 0.096 | 1.4 |
| 699-26-35C (deep) | 1/21/87 | 4 | 7.43 | 0.0425 | 0.206 | 2.8 |
| | 5/27/87 | 4 | 7.58 | 0.0025 | 0.050 | 0.7 |
| | 7/30/87 | 4 | 7.05 | 0.0033 | 0.058 | 0.8 |
| | 11/15/87 | 4 | 4.58 | 0.0292 | 0.171 | 3.7 |

Constituent Code[a], Name, Analysis Units = 199 $H_3O^+$

| Well Number | Sample Date | Replicates | Mean | Variance | Standard Deviation | Coefficient of Variation |
|---|---|---|---|---|---|---|
| 699-26-35A | 10/1/86 | 4 | 95E-9 | 11E-17 | 10E-9 | 10.8 |
| | 1/20/87 | 4 | 126E-9 | 0 | 0 | 0.0 |
| | 5/27/87 | 4 | 32E-9 | 0 | 0 | 0.0 |
| | 7/30/87 | 4 | 34E-9 | 17E-18 | 41E-10 | 12.2 |
| | 11/15/87 | 4 | 150E-9 | 27E-17 | 16E-9 | 10.8 |
| 699-26-34 | 10/1/86 | 4 | 76E-9 | 31E-17 | 18E-9 | 22.9 |
| | 1/21/87 | 4 | 109E-9 | 12E-16 | 34E-9 | 31.1 |
| | 5/26/87 | 4 | 28E-9 | 14E-18 | 38E-10 | 13.2 |
| | 7/30/87 | 4 | 106E-9 | 17E-17 | 13E-9 | 12.2 |
| | 11/15/87 | 4 | 242E-9 | 31E-16 | 55E-9 | 22.9 |
| 699-26-35C (deep) | 1/21/87 | 4 | 41E-9 | 36E-17 | 19E-9 | 46.3 |
| | 5/27/87 | 4 | 27E-9 | 11E-18 | 33E-10 | 12.2 |
| | 7/30/87 | 4 | 90E-9 | 14E-17 | 12E-9 | 13.2 |
| | 11/15/87 | 4 | 281E-7 | 10E-11 | 101E-7 | 36.1 |

9 2 1 2 5 4 1 0 7 2 5

# TABLE 7. (contd)

| Well Number | Sample Date | Replicates | Mean | Variance | Standard Deviation | Coefficient of Variation |
|---|---|---|---|---|---|---|
| Constituent Code[a], Name, Analysis Units = C68 TOX (ppb) | | | | | | |
| 699-26-35A | 1/20/87 | 4 | <100 | | | |
| | 5/27/87 | 4 | 7.8 | 42.25 | 6.50 | 83.3 |
| | 7/30/87 | 4 | 4.2 | 6.55 | 2.56 | 61.0 |
| 699-26-34 | 1/21/87 | 4 | <100 | | | |
| | 5/26/87 | 4 | 10.1 | 113.19 | 10.64 | 105.3 |
| | 7/30/87 | 4 | 5.6 | 5.27 | 2.30 | 40.8 |
| 699-26-35C (deep) | 1/21/87 | 4 | <100 | | | |
| | 5/27/87 | 4 | 0.9 | 2.89 | 1.70 | 200.0 |
| | 7/30/87 | 4 | 223.0 | 178.00 | 13.34 | 6.0 |
| Constituent Code[a], Name, Analysis Units = $H_4$2 TOXLDL (ppb) | | | | | | |
| 699-26-35A | 11/15/87 | 4 | 6.0 | 3.60 | 1.90 | 31.6 |
| 699-26-34 | 11/15/87 | 4 | 8.2 | 19.34 | 4.40 | 54.0 |
| 699-26-35C (deep) | 11/15/87 | 4 | 5.1 | 1.43 | 1.20 | 23.3 |
| Constituent Code[a], Name, Analysis Units = C69 TOC (ppb) | | | | | | |
| 699-26-35A | 1/20/87 | 4 | 321.0 | 1806 | 42.50 | 13.2 |
| | 5/27/87 | 4 | 493.0 | 13393 | 115.73 | 23.5 |
| | 7/30/87 | 4 | 405.0 | 3913 | 62.55 | 15.4 |
| | 11/15/87 | 4 | 1264.5 | 2710000 | 1646.30 | 130.2 |
| 699-26-34 | 1/21/87 | 4 | 336.3 | 2373 | 48.71 | 14.5 |
| | 5/26/87 | 4 | 375.5 | 3770 | 61.40 | 16.4 |
| | 7/30/87 | 4 | 444.3 | 1822 | 42.68 | 9.6 |
| | 11/15/87 | 4 | 460.0 | 28091 | 167.60 | 36.4 |
| 699-26-35C (deep) | 1/21/87 | 4 | 228.0 | 121 | 10.99 | 4.8 |
| | 5/27/87 | 4 | 329.0 | 3159 | 56.21 | 17.1 |
| | 7/30/87 | 4 | 381.8 | 8416 | 91.74 | 24.0 |
| | 11/15/87 | 3 | 297.0 | 11676 | 108.06 | 36.4 |

(a) Constituent Code is data base code for constituent
CONDFLD = Specific conductance (µmho) measured in the field.
PHFIELD = pH measured in the field.
$H_3O+$ = pH measured in units of $H_3O+$.
TOX = Total organic halogens (ppb) contractual detection limit of 100 ppb.
TOXLDL = Total organic halogens (ppb) contractual detection limit of 20 ppb.
TOC = Total organic carbon (ppb) contractual detection limit of 1000 ppb.

TABLE 8. Contamination-Indicator Parameters for Characterization of Averaged Replicate Background Data for the Nonradioactive Dangerous Waste Landfill

```
                         Constituent Code, Name, Analysis Units=191 CONDFLD umHO

                Moments                                          Quantiles(Def=4)                        Extremes

N                 11  Sum wgts          11  100% Max    410.5      99%       410.5      Lowest    Highest
Mean         359.568  Sum          3955.25   75% Q3       372      95%       410.5       281.5     360.75
Std dev      32.5615  Variance     1060.25   50% Med      359      90%      407.75      340.75        362
Skewness     -1.0516  Kurtosis     3.32472   25% Q1    357.25      10%      293.35      357.25        372
Uss          1432785  Css          10602.5    0% Min    281.5       5%       281.5      357.25     396.75
Cv           9.05572  Std Mean     9.81766                          1%       281.5       357.5      410.5
T:Mean=0     36.6246  Prob>|T|      0.0001  Range         129
Sgn rank          33  Prob>|S|   0.0038398  Q3-Q1       14.75
Num ^= 0          11                        Mode       357.25
W:Normal      0.8522  Prob<W         0.054

Stem leaf                  #  Boxplot                           Normal Probability plot
  40 1                     1     0          410+                                                 ++++++
  38 7                     1     0             |                                         +++++
  36 122                   3  +-------         |                                    ++++++*
  34 17789                 5  *------*      350+                          *  ***+++++
  32                                           |                        +++++
  30                                           |                   +++++
  28 2                     1     *          290+  +++++   *
     ------------------                         +----+----+----+----+----+----+----+----+----+----+
  Multiply stem.leaf by 10**+01                         -2        -1         0        +1        +2

Frequency table

                Percents                       Percents                          Percents
  Value Count  Cell   Cum       Value Count  Cell   Cum       Value Count  Cell   Cum
  281.5     1   9.1   9.1         359     1   9.1  54.5      396.75     1   9.1  90.9
 340.75     1   9.1  18.2      360.75     1   9.1  63.6       410.5     1   9.1 100.0
 357.25     2  18.2  36.4         362     1   9.1  72.7
  357.5     1   9.1  45.5         372     1   9.1  81.8
```

```
                         Constituent Code, Name, Analysis Units=C69 TOC       PPB

                Moments                                          Quantiles(Def=4)                        Extremes

N                 11  Sum wgts          11  100% Max      493      99%         493      Lowest    Highest
Mean         314.795  Sum          3462.75   75% Q3       405      95%         493          32      375.5
Std dev      138.618  Variance       19215   50% Med   336.25      90%      483.25         117     381.75
Skewness     -1.0053  Kurtosis    0.487236   25% Q1       228      10%          49         228        405
Uss          1282208  Css           192150    0% Min       32       5%          32         321     444.25
Cv           44.0344  Std Mean      41.795                          1%          32         329        493
T:Mean=0     7.53189  Prob>|T|      0.0001  Range         461
Sgn rank          33  Prob>|S|  0.00385729  Q3-Q1         177
Num ^= 0          11                        Mode           32
W:Normal     0.91194  Prob<W         0.325

Stem leaf                  #  Boxplot                           Normal Probability plot
   4 149                   3  +-------      450+                                          +++++++  *
   3 23488                 5  *------*         |                                  *  *+*+++++*
   2 3                     1  +-------      250+                             ++++++
   1 2                     1     |             |                      +++++*+
   0 3                     1     |           50+    +++++++
     ------------------                         +----+----+----+----+----+----+----+----+----+----+
  Multiply stem.leaf by 10**+02                         -2        -1         0        +1        +2

Frequency table

                Percents                       Percents                          Percents
  Value Count  Cell   Cum       Value Count  Cell   Cum       Value Count  Cell   Cum
     32     1   9.1   9.1         329     1   9.1  45.5         405     1   9.1  81.8
    117     1   9.1  18.2      336.25     1   9.1  54.5      444.25     1   9.1  90.9
    228     1   9.1  27.3       375.5     1   9.1  63.6         493     1   9.1 100.0
    321     1   9.1  36.4      381.75     1   9.1  72.7
```

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## TABLE 8. (contd)

---

Constituent Code, Name, Analysis Units=199 PHFIELD

| Moments | | | | Quantiles(Def=4) | | | | Extremes | |
|---|---|---|---|---|---|---|---|---|---|
| N | 11 | Sum wgts | 11 | 100% Max | 7.575 | 99% | 7.575 | Lowest | Highest |
| Mean | 7.23409 | Sum | 79.575 | 75% Q3 | 7.5 | 95% | 7.575 | 6.9 | 7.425 |
| Std dev | 0.267692 | Variance | 0.0716591 | 50% Med | 7.125 | 90% | 7.57 | 6.975 | 7.475 |
| Skewness | 0.141039 | Kurtosis | -2.1018 | 25% Q1 | 6.975 | 10% | 6.915 | 6.975 | 7.5 |
| Uss | 576.369 | Css | 0.716591 | 0% Min | 6.9 | 5% | 6.9 | 7.025 | 7.55 |
| Cv | 3.70043 | Std Mean | 0.0807122 | | | 1% | 6.9 | 7.05 | 7.575 |
| T:Mean=0 | 89.5282 | Prob>\|T\| | 0.0001 | Range | 0.675 | | | | |
| Sgn rank | 33 | Prob>\|S\| | 0.0038398 | Q3-Q1 | 0.525 | | | | |
| Num ^= 0 | 11 | | | Mode | 6.975 | | | | |
| W:Normal | 0.844015 | Prob<W | 0.045 | | | | | | |

```
Stem leaf                     #  Boxplot       7.55+                      Normal Probability plot
  75 057                      3     |               |                                         +*++   *
  74 27                       2  +-------+          |                               *  * *++
  73                             |       |          |                                 ++++
  72                             |   +   |          |                              +++*
  71 3                           1  *-------*          |                          ++++ *
  70 35                          2  |       |          |                     +++*  *
  69 077                         3  +-------+          |   *               +*****
  68                                           6.85+            *+++
     --------------------                          +----+----+----+----+----+----+----+----+----+----+
  Multiply stem.leaf by 10**-01                        -2        -1         0        +1        +2
```

Frequency table

| Value | Count | Percents Cell | Percents Cum | Value | Count | Percents Cell | Percents Cum | Value | Count | Percents Cell | Percents Cum |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.9 | 1 | 9.1 | 9.1 | 7.125 | 1 | 9.1 | 54.5 | 7.55 | 1 | 9.1 | 90.9 |
| 6.975 | 2 | 18.2 | 27.3 | 7.425 | 1 | 9.1 | 63.6 | 7.575 | 1 | 9.1 | 100.0 |
| 7.025 | 1 | 9.1 | 36.4 | 7.475 | 1 | 9.1 | 72.7 | | | | |
| 7.05 | 1 | 9.1 | 45.5 | 7.5 | 1 | 9.1 | 81.8 | | | | |

---

Constituent Code, Name, Analysis Units=199 H30+

| Moments | | | | Quantiles(Def=4) | | | | Extremes | |
|---|---|---|---|---|---|---|---|---|---|
| N | 11 | Sum wgts | 11 | 100% Max | 1.259E-07 | 99% | 1.259E-07 | Lowest | Highest |
| Mean | 6.946E-08 | Sum | 7.641E-07 | 75% Q3 | 1.065E-07 | 95% | 1.259E-07 | 2.674E-08 | 8.972E-08 |
| Std dev | 3.782E-08 | Variance | 1.430E-15 | 50% Med | 7.641E-08 | 90% | 1.226E-07 | 2.837E-08 | 9.486E-08 |
| Skewness | 0.110022 | Kurtosis | -1.8628 | 25% Q1 | 3.162E-08 | 10% | 2.707E-08 | 3.162E-08 | 1.065E-07 |
| Uss | 6.738E-14 | Css | 1.430E-14 | 0% Min | 2.674E-08 | 5% | 2.674E-08 | 3.367E-08 | 1.095E-07 |
| Cv | 54.4452 | Std Mean | 1.140E-08 | | | 1% | 2.674E-08 | 4.086E-08 | 1.259E-07 |
| T:Mean=0 | 6.09167 | Prob>\|T\| | .000116973 | Range | 9.915E-08 | | | | |
| Sgn rank | 33 | Prob>\|S\| | 0.00385729 | Q3-Q1 | 7.485E-08 | | | | |
| Num ^= 0 | 11 | | | Mode | 2.674E-08 | | | | |
| W:Normal | 0.868818 | Prob<W | 0.086 | | | | | | |

```
Stem leaf                     #  Boxplot     130E-9+                      Normal Probability plot
  12 6                        1     |               |                                          ++*++
  10 69                       2  +-------+          |                                   * ++*++
   8 05                       2  |       |          |                               *+*++++
   6 6                        1  *-------*          |                           ++*++
   4 1                        1  |       |          |                      ++++*+
   2 7824                     4  +-------+   300E-10+        *    *+++*+** *
     --------------------                          +----+----+----+----+----+----+----+----+----+----+
  Multiply stem.leaf by 10**-08                        -2        -1         0        +1        +2
```

Frequency table

| Value | Count | Percents Cell | Percents Cum | Value | Count | Percents Cell | Percents Cum | Value | Count | Percents Cell | Percents Cum |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.7E-08 | 1 | 9.1 | 9.1 | 4.1E-08 | 1 | 9.1 | 45.5 | 1.1E-07 | 1 | 9.1 | 81.8 |
| 2.8E-08 | 1 | 9.1 | 18.2 | 7.6E-08 | 1 | 9.1 | 54.5 | 1.1E-07 | 1 | 9.1 | 90.9 |
| 3.2E-08 | 1 | 9.1 | 27.3 | 9.0E-08 | 1 | 9.1 | 63.6 | 1.3E-07 | 1 | 9.1 | 100.0 |
| 3.4E-08 | 1 | 9.1 | 36.4 | 9.5E-08 | 1 | 9.1 | 72.7 | | | | |

## TABLE 8. (contd)

```
Constituent Code, Name, Analysis Units=C68 TOX     PPB

              Moments                                     Quantiles(Def=4)                       Extremes

N                  8  Sum wgts          8  100% Max        223      99%        223      Lowest    Highest
Mean         34.0344  Sum         272.275   75% Q3        12.8      95%        223        0.85          7
Std dev      76.4496  Variance    5844.55   50% Med        7.4      90%        223         4.2        7.8
Skewness     2.81427  Kurtosis     7.9398   25% Q1     4.55625      10%       0.85       5.625       10.1
Uss          50178.5  Css         40911.8    0% Min       0.85       5%       0.85           7       13.7
Cv           224.625  Std Mean     27 029                            1%       0.85         7.8        223
T:Mean=0     1.25918  Prob>|T|   0.248328  Range        222.15
Sgn rank          18  Prob>|S|  0.0142662  Q3-Q1       8.24375
Num ^= 0           8                       Mode           0.85
W:Normal    0.467352  Prob<W         <.01

Stem leaf                     #  Boxplot                        Normal Probability plot
   2 2                        1     *           225+                                          *        ++++
   1                                               |                                      ++++++
   1                                            125+                                ++++++++
   0                                               |                            ++++++
   0 0011111                  7  *-------*       25+          *      *     *+++*+++++  *    *
     -------------------                             +----+----+----+----+----+----+----+----+----+----+
  Multiply stem.leaf by 10**+02                           -2        -1         0        +1        +2

Frequency table

          Percents                      Percents                        Percents
Value Count  Cell   Cum     Value Count  Cell   Cum     Value Count  Cell   Cum
 0.85     1  12.5  12.5         7     1  12.5  50.0      13.7     1  12.5  87.5
  4.2     1  12.5  25.0       7.8     1  12.5  62.5       223     1  12.5 100.0
5.625     1  12.5  37.5      10.1     1  12.5  75.0
```

```
Constituent Code, Name, Analysis Units=C68 TOX     PPB

Without 30-Jul-87 TOX data from 6-26-35C

              Moments                                     Quantiles(Def=4)                       Extremes

N                  7  Sum wgts          7  100% Max       13.7      99%       13.7      Lowest    Highest
Mean         7.03929  Sum          49.275   75% Q3        10.1      95%       13.7        0.85      5.625
Std dev      4.13687  Variance    17.1137   50% Med          7      90%       13.7         4.2          7
Skewness    0.203692  Kurtosis   0.324865   25% Q1         4.2      10%       0.85       5.625        7.8
Uss          449.543  Css         102.682    0% Min       0.85       5%       0.85           7       10.1
Cv           58.7684  Std Mean    1.56359                            1%       0.85         7.8       13.7
T:Mean=0       4.502  Prob>|T| 0.00409521  Range         12.85
Sgn rank          14  Prob>|S|  0.0224943  Q3-Q1           5.9
Num ^= 0           7                       Mode           0.85
W:Normal    0.993927  Prob<W            1

Stem leaf                     #  Boxplot                        Normal Probability plot
  12 7                        1     |            13+                                              ++*++
  10 1                        1  +-------+         |                                          *+++
   8                             |       |         |                                      ++++
   6 08                       2  *-------*        7+                             ++*++ *
   4 26                       2  +-------+         |                   *++++*+
   2                                |              |              +++++
   0 8                        1     |             1+       ++*+*
     -------------------                             +----+----+----+----+----+----+----+----+----+----+
                                                          -2        -1         0        +1        +2

Frequency table

          Percents                      Percents                        Percents
Value Count  Cell   Cum     Value Count  Cell   Cum     Value Count  Cell   Cum
 0.85     1  14.3  14.3         7     1  14.3  57.1      13.7     1  14.3 100.0
  4.2     1  14.3  28.6       7.8     1  14.3  71.4
5.625     1  14.3  42.9      10.1     1  14.3  85.7
```

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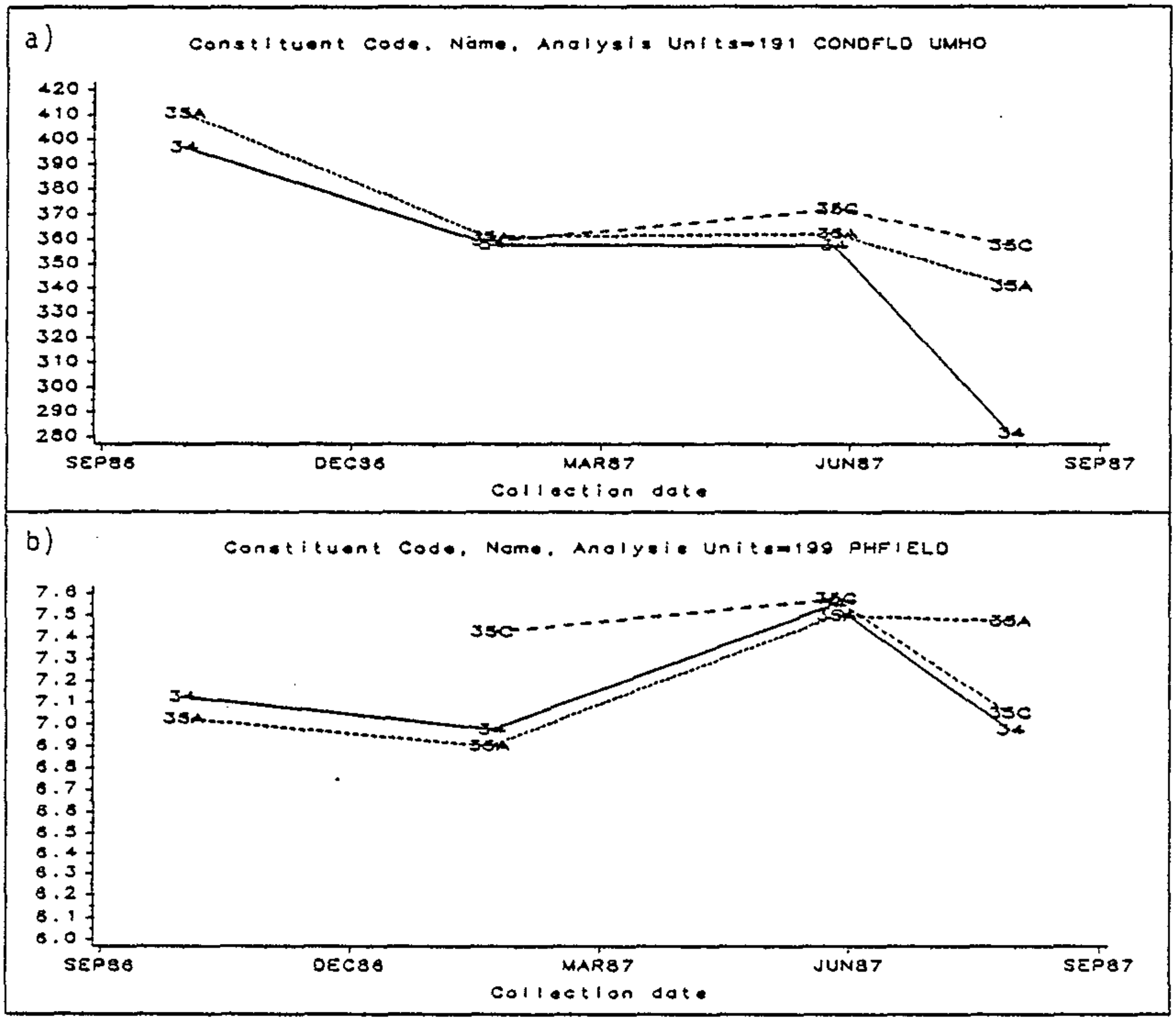


FIGURE 30. Characterization of Averaged Replicate Background Data from each of the Three Upgradient Nonradioactive Dangerous Waste Landfill Wells (699-26-35A, 699-26-35C, 699-26-34) for each of the Four Indicator Parameters. a) CONFLD=field conductivity ($\mu$mho); b) PHFLD=field pH; c) TOC=total organic carbon (ppb); d) and e) TOX=total organic halogens (ppb).

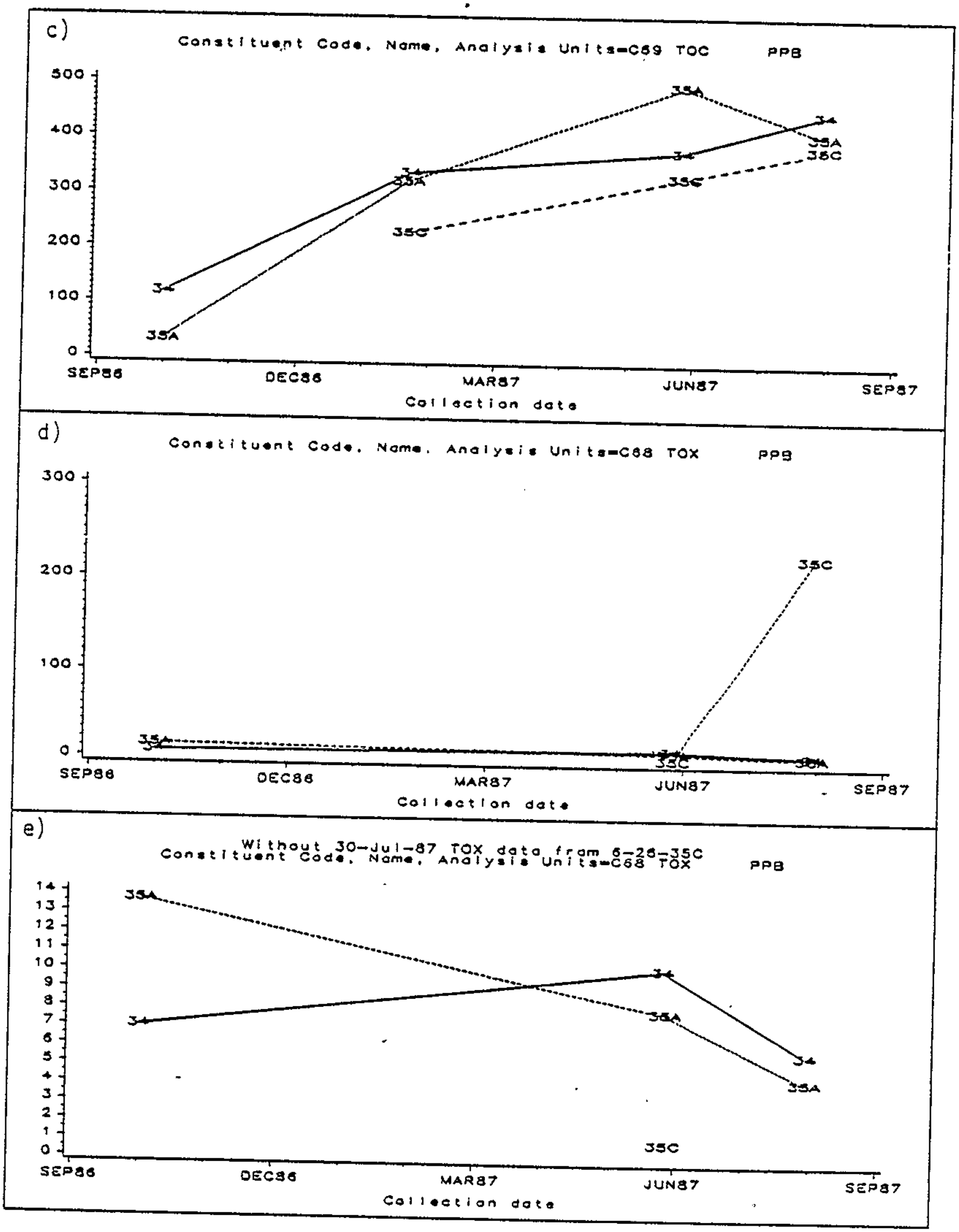


FIGURE 30. (contd)

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multiple comparisons that are being made. Four indicator parameters are being tested at each of the seven wells in the monitoring network, so that a total of 28 comparisons are made each time. The first step in the procedure is to determine the appropriate critical values to use for the test. The TEGD provides tables for this purpose; however some data are not available because of omissions during the first year of sample collection. Critical values need to be determined for points other than those given in the TEGD. The TEGD references Miller (1981), who uses the Bonferroni method, and gives both an approximate and an exact method for determining the critical values. Application of both of these methods has uncovered two concerns with the tables in the TEGD. The TEGD uses the approximation method given in Miller (1981), but several entries in the TEGD tables appear to be typographical errors. Also, the approximation method behaves very poorly, giving highly underestimated critical values for entries with small degrees of freedom (Table 9). This approximation method is probably used by many RCRA sites because it represents the minimum requirements for number of wells and frequency of sampling. Table 9 includes critical values for conditions that more closely reflect those at the NRDW for comparison with the TEGD tables and with other published critical value tables. Because the t-approximation method produces less meaningful results than the exact method (t-Beta), the latter will be used in the following analyses.

Statistical Evaluation

The TEGD states that there is a suggestion of contamination whenever $t^*$ (the difference of the background mean and the mean from the new sample divided by the standard error of the difference) exceeds $t_c$ (the critical value from the table). This is equivalent to saying there is a suggestion of contamination if the mean of a new sample at a well is greater than the background mean plus the critical value times the standard error. In this report, the value of the background mean plus the critical value times the standard error is called the critical mean. For example, if the mean from a new sample exceeds the critical mean, or is outside the range of two critical means for pH, then there is a suggestion of contamination using the TEGD guidance. Table 10 presents the critical mean values for the NRDW wells

TABLE 9. Critical Value Tables (EPA 1986)

| Test | Number of Wells | DF[a] | TAPPROX[b] | TBETA[c] | Ratio |
|---|---|---|---|---|---|
| One-tailed Test for Total Organic Halogens, Total Organic Carbon, Conductivity | 6 | 3 | 6.729 | 13.75 | 2.043 |
| | | 4 | 5.882 | 9.029 | 1.535 |
| | | 5 | 5.374 | 7.146 | 1.330 |
| | | 6 | 5.035 | 6.169 | 1.225 |
| | | 7 | 4.793 | 5.580 | 1.164 |
| | | 8 | 4.612 | 5.189 | 1.125 |
| | | 9 | 4.471 | 4.912 | 1.099 |
| | | 10 | 4.358 | 4.706 | 1.080 |
| | | 11 | 4.265 | 4.548 | 1.066 |
| | | 12 | 4.188 | 4.422 | 1.056 |
| | 7[d] | 3 | 6.895 | 14.48 | 2.100 |
| | | 4 | 6.018 | 9.398 | 1.562 |
| | | 5 | 5.491 | 7.388 | 1.345 |
| | | 6 | 5.140 | 6.351 | 1.236 |
| | | 7 | 4.889 | 5.728 | 1.172 |
| | | 8 | 4.701 | 5.316 | 1.131 |
| | | 9 | 4.555 | 5.025 | 1.103 |
| | | 10 | 4.437 | 4.809 | 1.084 |
| | | 11 | 4.342 | 4.642 | 1.069 |
| | | 12 | 4.262 | 4.510 | 1.058 |
| | 8 | 3 | 7.041 | 15.15 | 2.151 |
| | | 4 | 6.136 | 9.729 | 1.586 |
| | | 5 | 5.593 | 7.604 | 1.360 |
| | | 6 | 5.231 | 6.512 | 1.245 |
| | | 7 | 4.972 | 5.859 | 1.178 |
| | | 8 | 4.778 | 5.428 | 1.136 |
| | | 9 | 4.627 | 5.124 | 1.107 |
| | | 10 | 4.507 | 4.898 | 1.087 |
| | | 11 | 4.408 | 4.724 | 1.072 |
| | | 12 | 4.326 | 4.587 | 1.060 |
| Two-tailed Test for pH Parameter Only | 6 | 3 | 7.487 | 17.36 | 2.318 |
| | | 4 | 6.497 | 10.80 | 1.663 |
| | | 5 | 5.904 | 8.291 | 1.404 |
| | | 6 | 5.508 | 7.021 | 1.275 |
| | | 7 | 5.225 | 6.268 | 1.200 |
| | | 8 | 5.013 | 5.775 | 1.152 |
| | | 9 | 4.848 | 5.429 | 1.120 |
| | | 10 | 4.717 | 5.174 | 1.097 |
| | | 11 | 4.609 | 4.978 | 1.080 |
| | | 12 | 4.519 | 4.823 | 1.067 |

TABLE 9. (contd)

| Test | Number of Wells | DF[a] | TAPPROX[b] | TBETA[c] | Ratio |
|---|---|---|---|---|---|
| | 7[d] | 3 | 7.659 | 18.28 | 2.387 |
| | | 4 | 6.636 | 11.24 | 1.693 |
| | | 5 | 6.023 | 8.567 | 1.422 |
| | | 6 | 5.614 | 7.223 | 1.287 |
| | | 7 | 5.322 | 6.429 | 1.208 |
| | | 8 | 5.103 | 5.911 | 1.158 |
| | | 9 | 4.933 | 5.548 | 1.125 |
| | | 10 | 4.796 | 5.281 | 1.101 |
| | | 11 | 4.685 | 5.076 | 1.083 |
| | | 12 | 4.592 | 4.914 | 1.070 |
| | 8 | 3 | 7.808 | 19.12 | 2.449 |
| | | 4 | 6.757 | 11.63 | 1.721 |
| | | 5 | 6.127 | 8.812 | 1.438 |
| | | 6 | 5.707 | 7.401 | 1.297 |
| | | 7 | 5.406 | 6.571 | 1.216 |
| | | 8 | 5.181 | 6.031 | 1.164 |
| | | 9 | 5.006 | 5.653 | 1.129 |
| | | 10 | 4.866 | 5.375 | 1.105 |
| | | 11 | 4.751 | 5.162 | 1.087 |
| | | 12 | 4.656 | 4.994 | 1.073 |

(a) DF = degrees of freedom.
(b) TAPPROX is calculated using t-approximation in Miller (1981).
(c) TBETA is calculated using beta distribution.
(d) Number of wells at the Nonradioactive Dangerous Waste Landfill.



using the available background data. The TOX statistics calculated, including the high value obtained from the July sampling of well 699-26-35C, show that a new well average TOX value would have to be greater than 498.5 ppb to trigger a "flag" for possible contamination. It is assumed this concentration is unacceptable and, therefore, the TOX statistical calculations will be made without the high background TOX value.

TABLE 10. Critical Mean Values for the Nonradioactive Dangerous Waste Landfill

| Indication Parameter | Number of Background Means | DF[a] | $t_c$[b] | Background Average | Background Std. Dev. | Critical Mean |
|---|---|---|---|---|---|---|
| 191 Field Conductivity, $\mu$mho | 11 | 10 | 4.809 | 360 | 33 | 520 |
| 199 Field pH | 11 | 10 | 6.429 | 7.2 | 0.3 | (5.4,9.0) |
| C69 Total Organic Carbon, ppb | 11 | 10 | 4.809 | 310 | 140 | 1010 |
| C68 Total Organic Halogen, ppb | 8 | 7 | 5.728 | 34 | 76 | 490 |
| C68 Total Organic Halogen, ppb[c] | 7 | 6 | 6.351 | 7.0 | 4.1 | 35 |

(a) DF = degrees of freedom.
(b) $t_c$ = critical value (from Table 9).
(c) Calculated without July value in well 699-26-35C.

Mean values for monitoring data collected in October and November were compared with the critical means given in Table 7 with the following results:

- No new means exceeded 520.1 $\mu$mho for specific conductivity.
- Concentrations in deep, upgradient well 699-26-35C were outside of the critical range for pH, with a mean of 4.6. A mean pH of 4.6 has a high probability of being incorrect, indicating problems with field monitoring equipment. This will be reviewed before collection of future samples.
- No new means exceeded 35 ppb for TOX (using the lower detection limit).
- Water samples from three wells (699-25-33A, 699-26-33, and 699-26-35C) contained TOC concentrations that were greater than the critical mean for TOC, all being above 1010 ppb.

## SOLID WASTE LANDFILL

R. M. Fruland

The Solid Waste Landfill (SWL) and the NRDW compose the CLF. Because the sites are adjacent, data relating to the NRDW must be included along with data collected for the SWL.

Major activities of the detection-level ground-water monitoring project for the SWL completed during 1987 include the following:

- installation of six monitoring wells
- initial site characterization work
- four rounds of ground-water sampling and analysis.

The detection-level ground-water monitoring project at the SWL is based on WAC 173-304 (Ecology 1986a). One upgradient and five downgradient wells were installed between January and April 1987. All six SWL wells were completed in the top 15 ft of the unconfined aquifer. Figure 27 presents the well locations at the SWL and ground-water monitoring well locations at the NRDW. Ground-water monitoring at SWL wells began in May 1987 after ground-water sampling pumps were installed in the completed wells.

Table 11 presents the parameters required for ground-water monitoring programs at solid waste landfills.

Before the start of ground-water monitoring at the SWL, volatile organics had been detected in a Hanford Site ground-water monitoring well (699-24-33) a few hundred feet downgradient from the SWL. This well was being sampled as part of the site-wide Hanford Ground-Water Monitoring Project. Volatile organic analyses are not required by WAC 173-304 (Ecology 1986a); however, after the detection of volatile organics in well 699-24-33, this group of constituents was added to the list for all SWL well samples. Chlorinated hydrocarbons were detected in the first suite of ground-water samples from the SWL. The detection of these contaminants was reported by Pacific Northwest Laboratory (PNL) to the U.S. Department of Energy-Richland Operations Office (DOE-RL), and this information was transmitted by DOE-RL to Ecology. The detection notification included the statistical analysis of the

TABLE 11. Minimum Ground-Water Monitoring Parameters Required at Solid Waste Landfills[(a)]

| |
|---|
| Temperature |
| Conductivity |
| pH |
| Chloride |
| Nitrate, nitrite, and ammonia as nitrogen |
| Sulfate |
| Dissolved iron |
| Dissolved zinc |
| Dissolved manganese |
| Chemical oxygen demand |
| Total organic carbon |
| Total coliform bacteria |

(a) From WAC 173-304-490(2)(d)(i) (Ecology 1986a)

initial analytical results for the SWL. Simultaneously, resampling was initiated. As part of the resampling effort, the ground-water monitoring project was expanded to include essentially all hazardous constituents based on RCRA and WAC 173-303 regulations. The second round of analyses did not reveal the presence of additional hazardous wastes constituents in the ground water.

## WATER-LEVEL MEASUREMENTS

Determinations of the water-table elevation before sampling and annual determinations of the ground-water flow rate and direction in the uppermost aquifer are required by WAC 173-304. Figure 28 presents the ground-water flow direction, which is generally from west to east, in the vicinity of the CLF. Figure 29 shows water-level measurements taken in the NRDW and the Hanford Site ground-water monitoring wells. Regional data were used in planning the SWL and NRDW ground-water monitoring well networks. Figure 30 presents the ground-water flow direction determined for the NRDW as reported in Weekes, Luttrell, and Fuchs (1987). Figure 29 is based on the results of measurements made over a 7-day period. During the 7-day period, apparent direction of flow varied by as much as 90 degrees because of the large variability and uncertainties in the data (Weekes, Luttrell, and Fuchs 1987). The best available estimate of ground-water flow direction is based on observed regional west-to-east flow. Table 12 presents the water-level measurements at the SWL in 1987 and illustrates that quarterly water-level measurements are taken in conjunction with sample collection at the six SWL wells, and do not provide the quality of data needed to determine flow direction. The limited number and distribution of wells and the extended period of time between measurements at the various wells make the data inappropriate for determining flow direction.

Ground-water velocity for the upper portion of the unconfined aquifer was estimated to range from 2 to 5 ft/d, based on characterization work at the NRDW (Weekes, Luttrell, and Fuchs 1987). Characterization work at the SWL corroborates this range.

Determination of the ground-water quality at both upgradient and downgradient wells has been attempted for both the SWL and NRDW. These data are presented in Table 13. The first round of ground-water sampling at the SWL began in May 1987. Because contamination was detected, resampling was done in June 1987. The third quarter 1987 sampling was done at the end of July 1987, and the fourth quarter sampling was accomplished in two trips, one at



TABLE 12. Water-Level Measurements at the Solid Waste Landfill for 1987

| Well Number | Date | Water Level, ft above mean sea level |
|---|---|---|
| 699-24-35 | 5/20/87 | 404.35 |
| 699-23-34 | 5/20/87 | 404.27 |
| 699-24-34A | 5/20/87 | 404.27 |
| 699-24-34B | 5/20/87 | 404.28 |
| 699-24-34C | 5/20/87 | 404.27 |
| 699-23-34 | 7/28/87 | 404.42 |
| 699-24-34A | 7/28/87 | 404.39 |
| 699-24-34B | 7/28/87 | 404.35 |
| 699-24-34C | 7/27/87 | 404.38 |

TABLE 13. Statistical Analyses for the Central Landfill Chemical Monitoring Data

| Constituent | Average Upgradient | Downgradient Wells (699-) 23-34 | 24-34A | 24-34B | 24-33 | 24-34C | 25-34C | 25-34B | 25-34A | 26-33 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Indicators** | | | | | | | | | | |
| CONDFLD μmho | 358 | 484** | 455** | 484** | 475* | 460** | 342 | 381 | 377 | 369 |
| PHFIELD | 7.15 | 6.13** | 6.27** | 6.23** | 7.17 | 6.57* | 7.10 | 7.15 | 7.28 | 7.30 |
| TOC ppb | 350 | 399 | 390 | 397 | 388 | 415 | 531 | 325 | 316 | 673** |
| TOX[a] ppb | 7.9 | 68.8** | 39.2** | 56.8** | 27.8* | 24.4* | 8.2 | 15.1 | 5.9 | 20.8* |
| Volatile Organics[b] | | | | | | | | | | |
| 1,1,1-T ppb | 2.6 | 51.5** | 41.9** | 47.5** | 20.6** | 25.5** | 3.6 | 2.4 | ND | ND |
| TRICENE ppb | ND | 9.1** | 7.6** | 8.6** | 3.0** | 4.6** | ND | ND | ND | ND |
| PERCENE ppb | ND | 7.0** | 4.9** | 6.0** | 2.6** | 3 .3** | ND | ND | ND | ND |
| 1,1-DIC ppb | ND | 5.0** | 4.5** | 5.6** | ND | 2.4** | ND | ND | ND | ND |
| **Metals** | | | | | | | | | | |
| ZINC ppb | 13.5 | 43.3* | 64.0** | 34.0 | . | 82.0** | 34.0 | 6.0 | 6.0 | 6.3 |
| FZINC ppb | 13.4 | 32.7* | 39.3** | 27.7 | 6.3 | 73.3** | 29.3 | 6.0 | 5.5 | 6.0 |
| CALCIUM ppb | 37,900 | 69,500** | 68,000** | 67,500** | . | 58,800** | 40,200 | 37,400 | 37,500 | 35,900 |
| FCALCIU ppb | 35,900 | 64,600** | 62,300** | 64,600** | 57,600** | 57,000** | 37,400 | 34,100 | 33,800 | 31,100 |
| BARIUM ppb | 35.1 | 76.7** | 62.0** | 65.7** | 47.3 | 50.7 | 37.0 | 32.5 | 34.0 | 33.0 |
| FBARIUM ppb | 37.1 | 76.3** | 61.0* | 65.0** | 55.3 | 48.0 | 36.3 | 32.5 | 34.5 | 32.0 |
| SODIUM ppb | 22,500 | 22,900 | 22,900 | 22,700 | 23,500 | 22,500 | 22,600 | 22,900 | 22,800 | 22,800 |
| FSODIUM ppb | 22,500 | 22,200 | 22,500 | 22,700 | 22,900 | 22,300 | 22,600 | 22,300 | 22,400 | 22,200 |
| VANADUM ppb | 22.5 | 15.3* | 17.0* | 15.3* | 10.7 | 15.3* | 25.3 | 23.5 | 25.8 | 25.8 |
| FVANADI ppb | 23.7 | 16.3 | 16.7 | 16.0 | 17.0 | 12.7 | 21.3 | 23.0 | 25.0 | 22.5 |
| POTASUM ppb | 6,230 | 7,740** | 7,410** | 7,330** | 6,770* | 6,990* | 6,210 | 6,140 | 6,040 | 5,930 |
| FPOTASS ppb | 6,330 | 7,410* | 7,270 | 7,250 | 7,140 | 6,990 | 6,170 | 5,910 | 5,980 | 5,810 |

## TABLE 13. (contd)

| Constituent | Average Upgradient | Downgradient Wells (699-) 23-34 | 24-34A | 24-34B | 24-33 | 24-34C | 25-34C | 25-34B | 25-34A | 26-33 |
|---|---|---|---|---|---|---|---|---|---|---|
| Indicators | | | | | | | | | | |
| IRON ppb | 533 | 234 | 213 | 170 | 50 | 73 | 93 | 50 | 103 | 50 |
| MAGNES ppb | 10,700 | 16,300** | 15,100** | 15,600** | . | 14,800** | 11,300 | 10,700 | 10,700 | 10,300 |
| FMAGNES ppb | 10,600 | 15,700** | 15,100** | 15,600** | 14,800** | 14,800** | 11,200 | 10,500 | 10,300 | 9,670 |
| Anions | | | | | | | | | | |
| NITRATE ppb | 24,300 | 19,800 | 21,300 | 22,600 | 3,400 | 23,100 | 25,300 | 26,800 | 26,000 | 27,100 |
| SULFATE ppb | 43,000 | 47,500 | 47,000 | 44,900 | 47,800 | 44,500 | 41,900 | 41,200 | 40,900 | 39,600 |
| FLUORID ppb | 592 | 584 | 587 | 613 | 550 | 612 | 623 | 604 | 588 | 595 |
| CHLORID ppb | 7,850 | 8,470 | 8,410 | 8,640 | 8,400 | 8,330 | 8,170 | 7,930 | 7,620 | 7,360 |
| Miscellaneous | | | | | | | | | | |
| AMMONIU ppb | 59.3 | 61.3 | 51.7 | 58.3 | 76.7 | 65.3 | 66.7 | . | . | . |
| BETA pCi/L | 28.9 | 23.8 | 21.9 | 22.3 | 23.5 | 27.9 | 16.7 | 27.8 | 26.4 | 25.9 |
| LOALPHA pCi/L | 3.17 | 3.95 | 2.32 | 2.38 | 3.68 | 3.72 | 3.08 | 2.59 | 3.17 | 2.29 |
| TC ppb | 27,800 | . | . | . | 46,100 | . | . | 28,900 | 28,100 | 27,300 |

** - Statistically significant at p <0.01
 * - Statistically significant at p <0.05
(a) Combined TOX and TOXLDL data, did not use January 1987 data, deleted one high value of 270 at 6-25-34B
 Used reported data, even if below contractual detection of 100 for TOX and 20 for TOXLDL.
(b) For volatile organics, used reported data even if below contractual detection limit of 10 ppb.
 Value of 2 was used for nondetected (ND) organics in statistical analyses of 1,1,1-T.
 Data for TRICENE, PERCENE, and 1,1-DIC were analyzed using Fisher's exact probability test.
TOX = Total Organic Halogens
TOXLDL = Total Organic Halogens, Lower Detection Limit
1,1,1-T = 1,1,1-trichloroethane
Tricene = Trichloroethylene
Percene = Perchloroethylene
1,1,-Dic = 1,1-dichlorethane
(c) "F" before a constituent indicates a filtered sample; no "F" indicates an unfiltered water sample
magnes = magnesium
TC = total carbon

the end of October and one in the middle of November. Analyses of the fourth quarter samples had not been completed by the analytical laboratory by the end of 1987; therefore, downgradient water-quality data are summarized for the first three sampling rounds in 1987.

It is evident that SWL operations have affected the ground water at the downgradient wells. Five chlorinated hydrocarbon constituents were detected, which, not occurring naturally, must represent contamination. However, only one constituent, TCE, is above the EPA's 5-ppb MCL. The TCE concentrations range from around the detection limit to approximately twice the detection limit.



STATISTICAL ANALYSIS OF GROUND-WATER CHEMISTRY DATA

Both of the regulatory programs at the CLF require specific statistical analyses to be performed after 1 year of sample collection and analysis. It is the intent of this section to analyze the data for 1987 to provide CLF site characterization, rather than project-specific detection-monitoring analysis. Only those contaminants that were detected in several of the wells were considered for statistical analysis.

Summaries of the results of the statistical analyses are given in Table 13. For each constituent analyzed, the average of the upgradient wells is given in the second column. Each subsequent column gives the average for the constituent at the identified well. Also included are the results of the statistical tests, with wells that are statistically different from the upgradient wells at the (probability) $p < 0.01$ and $p < 0.05$ significance levels.

It is evident from the results of these analyses that the four southernmost downgradient wells from the SWL and well 699-24-33 exhibit differences for several constituents, specifically in the contamination indicators, several major constituents, metals, and volatile organics. Because volatile organics do not occur in nature and are basically not present in the upgradient wells, it is concluded that they are coming from the SWL.

Differences in metals concentrations could be explained by differences in the underlying geochemistry of the site. However, these differences occur in the same wells as the volatile organic contamination, suggesting that the detected metals also represent contamination coming from the CLF.

RESPONSE

In the future, monthly water-level measurements will be taken at the SWL, NRDW, and other Hanford Site wells in the vicinity of the CLF. This approach should allow a more precise determination of ground-water flow and flow variations in the vicinity of the CLF.

Investigation into the source of the detected chlorinated hydrocarbons found that washwater discharges to the SWL from January 1985 to January 1987 contained a number of solvents in low concentrations. This washwater, from the 1100 Area bus maintenance operations, appears to be the source of the chlorinated hydrocarbons. Sewage from Hanford Site facility operations chemical toilets has been discharged to the SWL, but this practice was discontinued in April 1987. A soil/gas survey was performed at the CLF in November 1987 to determine if the washwater was the only source of contamination and to locate any other potential problems at the SWL or NRDW. Results will be reported in 1988.

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